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Canadian Intellectual Property Office
An agency of Industry Canada

CA 2393022 A1 2002/04/04

(21) 2 393 022

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2001/09/28
(87) Date publication PCT/PCT Publication Date: 2002/04/04
(85) Entrée phase nationale/National Entry: 2002/05/27
(86) N° demande PCT/PCT Application No.: JP 2001/008578
(87) N° publication PCT/PCT Publication No.: 2002/027399
(30) Priorités/Priorities: 2000/09/29 (2000-300937) JP; 2001/07/18 (PCT/JP01/06250) JP

(51) Cl.Int.^{7}/Int.Cl.^{7} G03B 21/60, B29C 33/38, B29C 39/26, B23B 27/20, B29C 39/02, B23B 5/00, G02B 3/08

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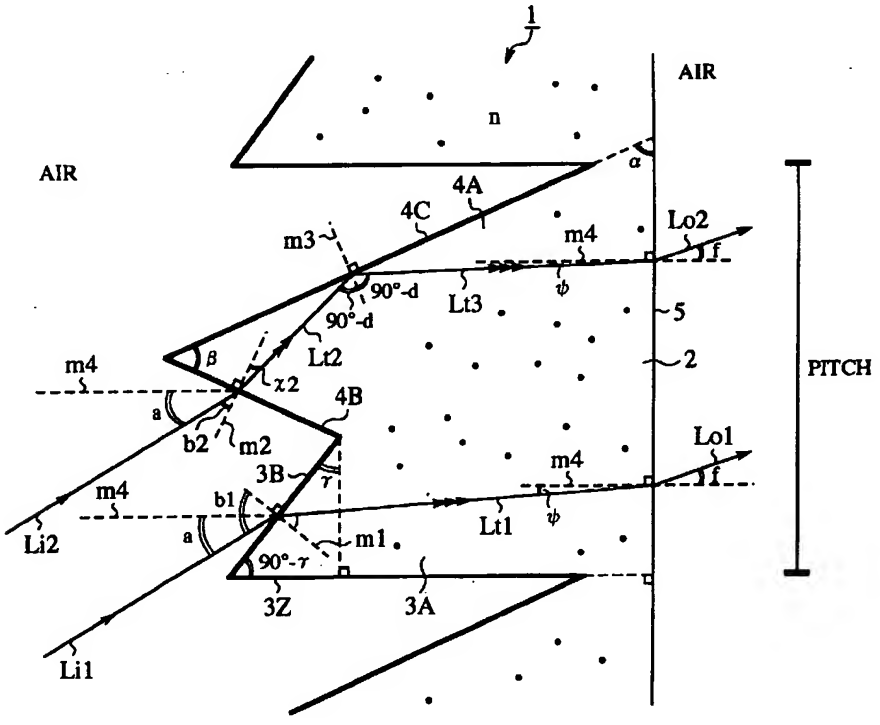
(54) Titre : LENTILLE DE FRESNEL, ECRAN, DISPOSITIF D'AFFICHAGE D'IMAGE, PROCEDE DE FABRICATION DE MOULES POUR LENTILLES ET PROCEDE DE FABRICATION DE LENTILLES

(54) Title: FRESNEL LENS, SCREEN, IMAGE DISPLAY DEVICE, LENS MOLD MANUFACTURING METHOD, AND LENS MANUFACTURING METHOD



(57) Abrégé/Abstract:
A Fresnel lens has a pitch including a hybrid prism comprising a refraction prism unit (3A) for emitting an incident light (li1) of an incident angle (a) as an outgoing light (lo1) of an outgoing angle (f) by two refractions, and a total reflection prism unit (4A) for emitting an incident light (li2) of an incident angle (a) as an outgoing light (lo2) parallel to the outgoing light (lo1) by a refraction, a total reflection, and a refraction.

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ABSTRACT OF THE DISCLOSURE

A Fresnel lens has a plurality of pitch areas in which a plurality of hybrid type prism portions are arranged. Each hybrid type prism portion has a refraction type prism portion and a total reflection type prism portion. In the refraction type prism portion, a ray of incident light Li1 of an incident angle "a" is refracted twice and goes out as a ray of outgoing light Lo1 of an outgoing angle "f". In the total reflection type prism portion, a ray of incident light Li2 of the incident angle "a" is refracted, totally reflected and refracted in that order and goes out as a ray of outgoing light Lo2 parallel to the ray of outgoing light Lo1.

WHAT IS CLAIMED IS:

1. A Fresnel lens, comprising:

a pitch area having a hybrid type prism portion which has both a refraction type prism portion for making a ray of first incident light having a prescribed incident angle go out according to a first refraction phenomenon and a second refraction phenomenon as a ray of first outgoing light having a prescribed outgoing angle; and

a total reflection prism portion for making a ray of second incident light having the prescribed incident angle go out according to a third refraction phenomenon, a total reflection phenomenon and a fourth refraction phenomenon as a ray of second outgoing light parallel to the ray of first outgoing light.

2. A Fresnel lens according to claim 1, further comprising another pitch area having the hybrid type prism portion or a plurality of other pitch areas having the hybrid type prism portions respectively, wherein a ratio of an area occupied by the refraction type prism portion to an area occupied by the hybrid type prism portion in each pitch area differs from ratios in the other pitch areas.

3. A Fresnel lens, in which a ray of incident light having a prescribed incident angle goes out through a prism portion as a ray of outgoing light having a prescribed outgoing angle for each pitch area, comprising:

a plurality of pitch areas respectively having a hybrid type prism portion which has both a refraction type prism portion and a total reflection prism portion integrally formed with each other, wherein a sectional shape of the refraction type prism portion of each pitch area is formed by:

a first incident plane for changing a ray of first incident light

incident at a prescribed incident angle to a ray of first transmitted light according to a first refraction phenomenon;

a plane-shaped outgoing plane for changing the ray of first transmitted light obtained on the first incident plane to a ray of first outgoing light having a prescribed outgoing angle according to a second refraction phenomenon; and

an ineffective plane connecting with the first incident plane and an adjacent pitch area,

a sectional shape of the total reflection type prism portion of each pitch area is formed by:

a second incident plane for changing a ray of second incident light incident at the prescribed incident angle to a ray of second transmitted light according to a third refraction phenomenon;

a total reflection plane for changing the ray of second transmitted light obtained on the second incident plane to a ray of third transmitted light parallel to the ray of first transmitted light according to a total reflection phenomenon; and

the outgoing plane of the refraction type prism portion,

the ray of third transmitted light obtained in the total reflection plane is changed to a ray of second outgoing light having the prescribed outgoing angle according to a fourth refraction phenomenon on the outgoing plane, and

a portion of the ray of second incident light not changed to the ray of third transmitted light is received as the ray of first incident light.

4. A Fresnel lens according to claim 3, wherein the second incident plane of each pitch area is formed in a sectional shape so as to make the second incident plane conceal the ineffective plane of the hybrid type prism portion arranged in an adjacent pitch from a view seen in

a direction of a ray of ineffective light incident on the ineffective plane, and the total reflection plane of each pitch area is formed in a second incident plane compensating shape so as to compensate for the sectional shape of the second incident plane.

5. A Fresnel lens according to claim 3, wherein a small incident angle region is determined according to a characteristic changing angle at which transmissivity of the hybrid type prism portion is equal to that of the refraction type prism portion, and the refraction type prism portion is arranged in each of pitch areas placed in the small incident angle region.

6. A Fresnel lens according to claim 4, wherein a small incident angle region is determined according to a characteristic changing angle at which transmissivity of the hybrid type prism portion is equal to that of the refraction type prism portion, and the refraction type prism portion is arranged in each of pitch areas placed in the small incident angle region.

7. A Fresnel lens according to claim 5, wherein a mixing ratio of the refraction type prism portion to the hybrid type prism portion is increased with the decrease of the incident angle in each of pitch areas corresponding to a characteristic changing region neighboring to the characteristic changing angle.

8. A Fresnel lens according to claim 6, wherein a mixing ratio of the refraction type prism portion to the hybrid type prism portion is increased with the decrease of the incident angle in each of pitch areas corresponding to a characteristic changing region neighboring to the characteristic changing angle.

9. A Fresnel lens according to claim 5, wherein an intermediary prism portion is arranged as one hybrid type prism portion in each of pitch areas corresponding to a characteristic changing region neighboring to the characteristic changing angle, an area of the second incident plane of the intermediary prism portion is slightly decreased with the decrease of the incident angle, and an area of the first incident plane of the intermediary prism portion is slightly increased with the decrease of the incident angle.

10. A Fresnel lens according to claim 6, wherein an intermediary prism portion is arranged as one hybrid type prism portion in each of pitch areas corresponding to a characteristic changing region neighboring to the characteristic changing angle, an area of the second incident plane of the intermediary prism portion is slightly decreased with the decrease of the incident angle, and an area of the first incident plane of the intermediary prism portion is slightly increased with the decrease of the incident angle.

11. A Fresnel lens according to claim 3, wherein a top blade angle between the second incident plane and the total reflection plane is set to a most-acute angle in a range in which an angle between the second incident plane and the outgoing plane is not obtuse.

12. A Fresnel lens according to claim 11, wherein the top blade angle is set to an angle larger than the most-acute angle in a small incident angle region corresponding to incident angles smaller than a specific incident angle at which transmissivity corresponding to the top blade angle set to the most-acute angle is equal to transmissivity corresponding to the top blade angle different from the most-acute

angle.

13. A Fresnel lens according to claim 3, wherein the prescribed outgoing angle is set to a value larger than zero degree in each of pitch areas corresponding to incident angles at which transmissivity of the hybrid type prism portions is decreased.

14. A Fresnel lens according to claim 3, wherein the Fresnel lens is cut out in a rectangular shape so as to have four sides, a boundary ring band of the Fresnel lens intersects only one side nearest to an optical axis among the four sides of the Fresnel lens, the outgoing angle is set so as to make the ray of first outgoing light and the ray of second outgoing light going out on a lens periphery side of the boundary ring band be parallel to the optical axis, and the outgoing angle of the ray of first outgoing light and the ray of second outgoing light going out on an optical axis side of the boundary ring band is set to a value larger than that corresponding to the ray of first outgoing light and the ray of second outgoing light going out in parallel to the optical axis.

15. A Fresnel lens according to claim 3, wherein each refraction type prism portion has a thin-film light absorbing layer on the ineffective layer, and the thin-film light absorbing layer absorbs light.

16. A Fresnel lens according to claim 3, further comprising:
a stray light absorbing plate which is arranged on the outgoing plane and has a plurality of light transmitting layers and a plurality of light absorbing layers alternately layered almost in parallel to an optical axis of the Fresnel lens, wherein a ray of light is transmitted through each light transmitting layer, and light is absorbed in each

light absorbing layer.

17. A Fresnel lens according to claim 16, wherein the stray light absorbing plate arranged on the outgoing plane is integrally formed with the Fresnel lens.

18. A Fresnel lens according to claim 16, wherein the light transmitting layers and the light absorbing layers are layered in a concentric circular shape while centering around the optical axis of the Fresnel lens.

19. A Fresnel lens according to claim 16, wherein the light transmitting layers and the light absorbing layers are layered in a direction almost in parallel to each other.

20. A Fresnel lens according to claim 3, further comprising:
a light absorbing plate, arranged on the outgoing layer, for absorbing light.

21. A Fresnel lens according to claim 3, wherein the hybrid type prism portions are formed while having a pitch margin between each pair of pitch areas adjacent to each other.

22. A Fresnel lens according to claim 3, further comprising:
a group of pitch areas in which a plurality of dummy prism portions are successively arranged, wherein a height of each dummy prism portion in an optical axis direction is set not to have relation to the reception of light.

23. A screen, comprising:

the Fresnel lens according to one of claims 1 to 22; and

an image forming and diffusing means for receiving the ray of outgoing light, to which display contents are added, from the Fresnel lens, forming an image from the ray of outgoing light and diffusing the image.

24. A screen according to claim 23, wherein the image forming and diffusing means is arranged on the outgoing plane to be integrally formed with the Fresnel lens.

25. An image displaying device, comprising:

the screen according to claim 23 or 24;

illumination light source means for emitting a plurality of rays of light almost parallel to each other;

converging optics means for converging the rays of light emitted from the illumination light source means;

optical modulating means for spatially changing intensities of the rays of light converged by the converging optics means so as to modulate the rays of light according to the display contents; and

projection optics means for projecting the rays of light modulated by the optical modulating means onto the screen.

26. A Fresnel lens, comprising:

a plurality of total reflection type prism portions which are arranged on a light incident side and respectively have both a second incident plane, on which a plurality of rays of light are incident, and a total reflection plane on which a part of the rays of light are totally reflected and are deflected in a desired direction,

wherein each total reflection type prism portion has a subsidiary unit-prism portion arranged in a part of the second incident plane on which a ray of light expected not to be totally reflected on the

total reflection plane is incident, and
the subsidiary unit-prism portion functions as a refraction type prism portion having a first incident plane on which the ray of incident light is refracted to be deflected in the desired direction.

27. A Fresnel lens according to claim 26, wherein a plane obtained by extending the first incident plane of each subsidiary unit-prism portion is placed in a position shifted from the total reflection plane toward a light outgoing side in a range of the corresponding total reflection type prism portion.

28. A Fresnel lens according to claim 26, wherein a ratio of each subsidiary unit-prism portion to the corresponding second incident plane differs from those of the other subsidiary unit-prism portions.

29. A Fresnel lens according to claim 27, wherein a ratio of each subsidiary unit-prism portion to the corresponding second incident plane differs from those of the other subsidiary unit-prism portions.

30. A Fresnel lens, comprising:
a plurality of refraction type prism portions which are arranged on a light incident side and respectively have both a first incident plane, on which a ray of incident light is refracted to be deflected in a desired direction, and an ineffective plane different from the first incident plane,
wherein each refraction type prism portion has a subsidiary unit-prism portion arranged on the first incident plane, a ray of light expected to be incident on the ineffective plane of another adjacent refraction type prism portion placed on a Fresnel periphery side is received in the subsidiary unit-prism portion, and

the subsidiary unit-prism portion functions as a total reflection type prism portion having both a second incident plane, on which a ray of light is received, and a total reflection plane on which the ray of light received on the second incident plane is totally reflected to be deflected in the desired direction.

31. A Fresnel lens according to claim 30, wherein a plane obtained by extending the second incident plane of each subsidiary unit-prism portion is placed in a position shifted from the ineffective plane toward a light outgoing side in a range of the corresponding refraction type prism portion.

32. A Fresnel lens according to claim 30, wherein a ratio of each subsidiary unit-prism portion to the corresponding first incident plane differs from those of the other subsidiary unit-prism portions.

33. A Fresnel lens according to claim 31, wherein a ratio of each subsidiary unit-prism portion to the corresponding first incident plane differs from those of the other subsidiary unit-prism portions.

34. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 26; and

a second region indicating the same shape as that of the Fresnel lens according to claim 30.

35. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 26; and

a second region indicating the same shape as that of the Fresnel

lens according to claim 31.

36. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 26; and

a second region indicating the same shape as that of the Fresnel lens according to claim 32.

37. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 26; and

a second region indicating the same shape as that of the Fresnel lens according to claim 33.

38. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 27; and

a second region indicating the same shape as that of the Fresnel lens according to claim 30.

39. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 27; and

a second region indicating the same shape as that of the Fresnel lens according to claim 31.

40. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 27; and

a second region indicating the same shape as that of the Fresnel

lens according to claim 32.

41. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 27; and

a second region indicating the same shape as that of the Fresnel lens according to claim 33.

42. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 28; and

a second region indicating the same shape as that of the Fresnel lens according to claim 30.

43. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 28; and

a second region indicating the same shape as that of the Fresnel lens according to claim 31.

44. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 28; and

a second region indicating the same shape as that of the Fresnel lens according to claim 32.

45. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 28; and

a second region indicating the same shape as that of the Fresnel

lens according to claim 33.

46. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 29; and

a second region indicating the same shape as that of the Fresnel lens according to claim 30.

47. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 29; and

a second region indicating the same shape as that of the Fresnel lens according to claim 31.

48. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 29; and

a second region indicating the same shape as that of the Fresnel lens according to claim 32.

49. A Fresnel lens, comprising:

a first region indicating the same shape as that of the Fresnel lens according to claim 29; and

a second region indicating the same shape as that of the Fresnel lens according to claim 33.

50. A Fresnel lens according to claim 34, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second

region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

51. A Fresnel lens according to claim 35, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

52. A Fresnel lens according to claim 36, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased

as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

53. A Fresnel lens according to claim 37, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

54. A Fresnel lens according to claim 38, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first

incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

55. A Fresnel lens according to claim 39, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

56. A Fresnel lens according to claim 40, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the

subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

57. A Fresnel lens according to claim 41, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

58. A Fresnel lens according to claim 42, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism

portion is far away from the boundary.

59. A Fresnel lens according to claim 43, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

60. A Fresnel lens according to claim 44, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

61. A Fresnel lens according to claim 45, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

62. A Fresnel lens according to claim 46, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

63. A Fresnel lens according to claim 47, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident

plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

64. A Fresnel lens according to claim 48, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

65. A Fresnel lens according to claim 49, wherein a ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is increased as the subsidiary unit-prism portion approaches a boundary between the first region and the second

region, the ratio of the subsidiary unit-prism portion to the corresponding second incident plane in the first region is decreased as the subsidiary unit-prism portion is far away from the boundary, a ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is increased as the subsidiary unit-prism portion approaches the boundary, and the ratio of the subsidiary unit-prism portion to the corresponding first incident plane in the second region is decreased as the subsidiary unit-prism portion is far away from the boundary.

66. A Fresnel lens according to claim 26, wherein a second Fresnel lens different from the Fresnel lens arranged on a plane of the light incident side is arranged on a plane of a light outgoing side of the Fresnel lens.

67. A Fresnel lens according to claim 30, wherein a second Fresnel lens different from the Fresnel lens arranged on a plane of a light incident side is arranged on a plane of a light outgoing side of the Fresnel lens.

68. A screen, comprising:

the Fresnel lens according to one of claims 26 to 65; and

light diffusing means, arranged on a plane of a light outgoing side of the Fresnel lens, for diffusing the rays of light going out from the Fresnel lens.

69. A screen, comprising:

the Fresnel lens according to claim 66 or 67; and

light diffusing means, arranged on a light outgoing side of the Fresnel lens, for diffusing the rays of light going out from the Fresnel

lens.

70. An image displaying device, comprising:
the screen according to claim 68;
an image light source for emitting a plurality of rays of image light; and
projection optics means for projecting the rays of image light emitted from the image light source onto the screen.

71. An image displaying device, comprising:
the screen according to claim 69;
an image light source for emitting a plurality of rays of image light; and
projection optics means for projecting the rays of image light emitted from the image light source onto the screen.

72. A method of manufacturing a lens forming mold, in which a lens forming mold is cut in a reversed shape of both a refractive type prism portion and a total reflection type prism portion formed for each pitch area of a Fresnel lens by using a cutting tool, comprising:
a main unit-prism portion cutting step of cutting the lens forming mold in a reversed shape of the refractive type prism portion of a cutting pitch area by using the cutting tool; and
a subordinate unit-prism portion cutting step of cutting the lens forming mold in a reversed shape of the total reflection type prism portion of the cutting pitch area by using the cutting tool on condition that a plane obtained by extending a total reflection plane in the reversed shape of the total reflection type prism portion intersects a trough line placed between the cutting pitch area and another cutting area adjacent to the cutting pitch area on a Fresnel center side or

pass through an area shifted from the trough line toward a light outgoing side, wherein the combination of the main unit-prism portion cutting step and the subordinate unit-prism portion cutting step is repeatedly performed by a prescribed number equal to the number of cutting pitch areas.

73. A method of manufacturing a lens forming mold, in which a lens forming mold is cut in a reversed shape of both a refractive type prism portion and a total reflection type prism portion formed for each pitch area of a Fresnel lens by using a cutting tool, comprising:

a main unit-prism portion cutting step of cutting the lens forming mold in a reversed shape of the total reflection type prism portion of a cutting pitch area by using the cutting tool; and

a subordinate unit-prism portion cutting step of cutting the lens forming mold in a reversed shape of the refractive type prism portion of the cutting pitch area by using the cutting tool on condition that a plane obtained by extending a first incident plane in the reversed shape of the refractive type prism portion intersects a trough line placed between the cutting pitch area and another cutting area adjacent to the cutting pitch area on a Fresnel periphery side or pass through an area shifted from the trough line toward a light outgoing side, wherein the combination of the main unit-prism portion cutting step and the subordinate unit-prism portion cutting step is repeatedly performed by a prescribed number equal to the number of cutting pitch areas.

74. A method of manufacturing a lens forming mold according to claim 72, further comprising:

a pitch margin setting step for setting a pitch margin for each cutting pitch area before the subordinate unit-prism portion cutting

step in cases where the lens forming mold is cut in a cut performing direction from the Fresnel center side to a Fresnel periphery side in the order of the total reflection type prism portion and the refractive type prism portion,

wherein the subordinate unit-prism portion cutting step comprises the steps of:

shifting a cutting start position toward the cut performing direction by the pitch margin; and

cutting the lens forming mold to form the reversed shape of the refractive type prism portion for each cutting pitch area.

75. A method of manufacturing a lens forming mold according to claim 73, further comprising:

a pitch margin setting step for setting a pitch margin for each cutting pitch area before the subordinate unit-prism portion cutting step in cases where the lens forming mold is cut in a cut performing direction from a Fresnel periphery side to the Fresnel center side in the order of the refractive type prism portion and the total reflection type prism portion,

wherein the subordinate unit-prism portion cutting step comprises the steps of:

shifting a cutting start position toward the cut performing direction by the pitch margin; and

cutting the lens forming mold to form the reversed shape of the total reflection type prism portion for each cutting pitch area.

76. A method of manufacturing a lens forming mold according to claim 73, further comprising the step of:

successively cutting the lens forming mold in a reversed shape of a plurality of dummy prism portions respectively having a height in

an optical axis direction not related to the reception of light for a group of pitch areas.

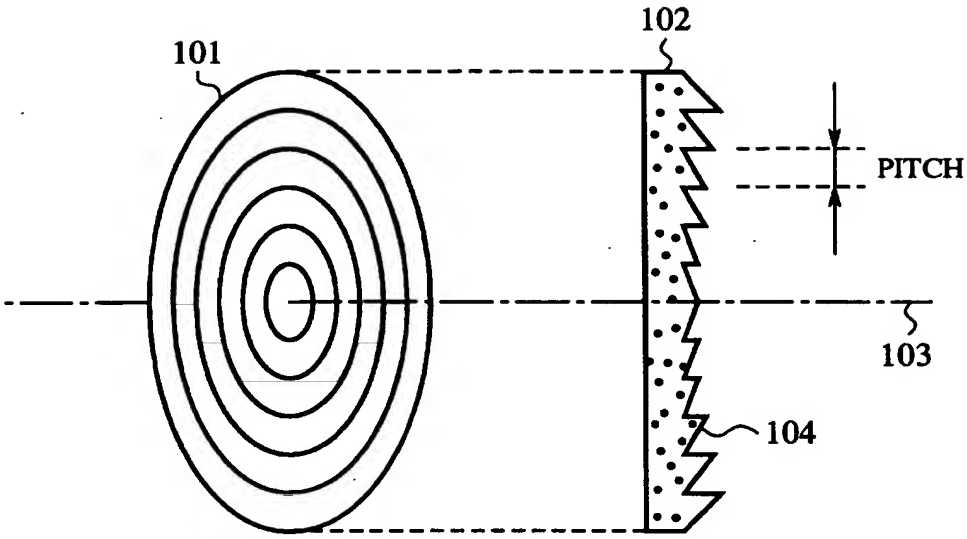
77. A method of manufacturing a lens, comprising the steps of:

pouring resin into a lens forming mold manufactured in the method of manufacturing a lens forming mold according to one of claims 72 to 76;

hardening the resin; and

taking off the lens forming mold from the hardened resin to form a lens.

FIG.1



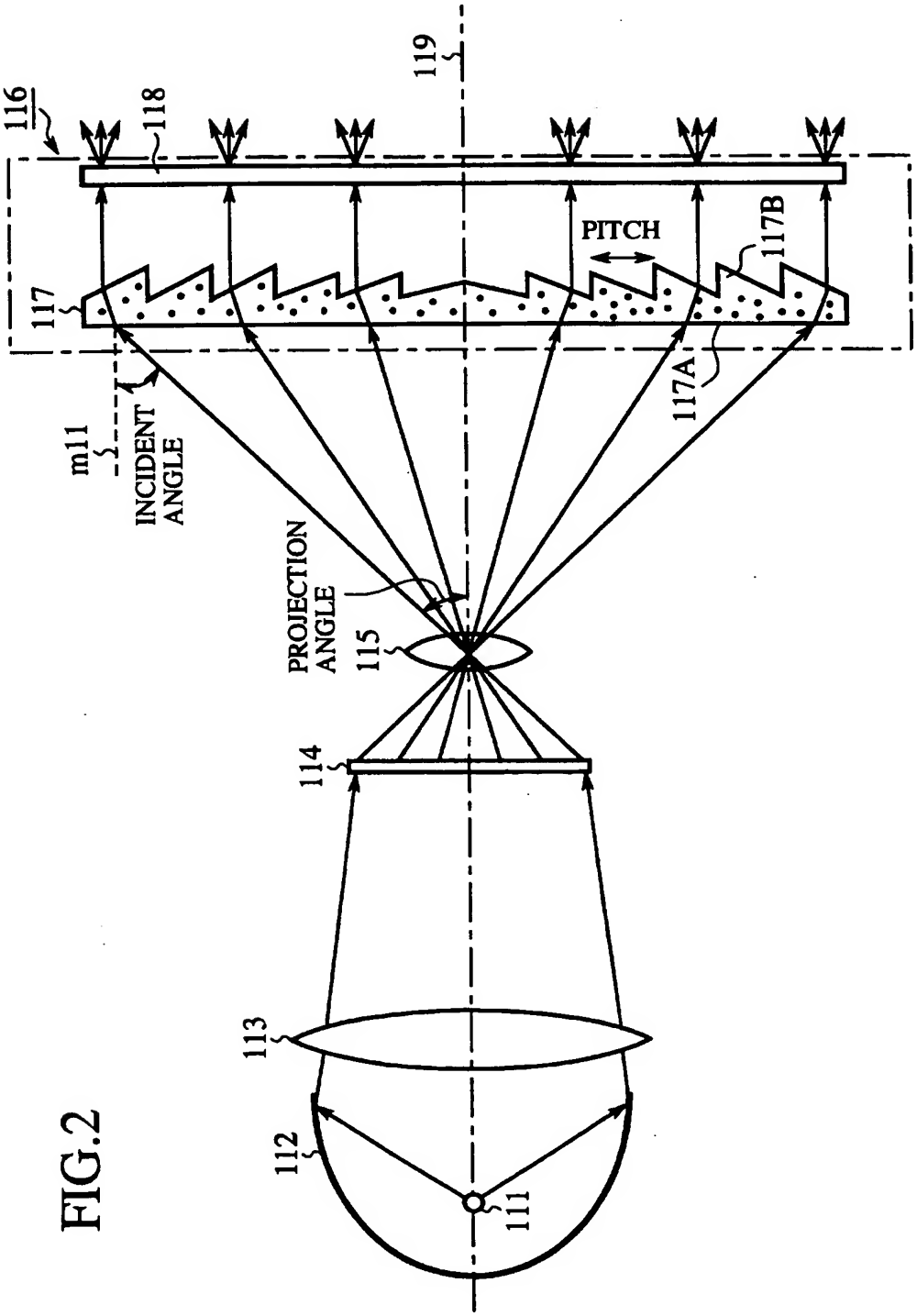

119
116
118
PITCH
117B
117
117A
m11
INCIDENT ANGLE
PROJECTION ANGLE
115
114
113
112
111

FIG.2

FIG.3B

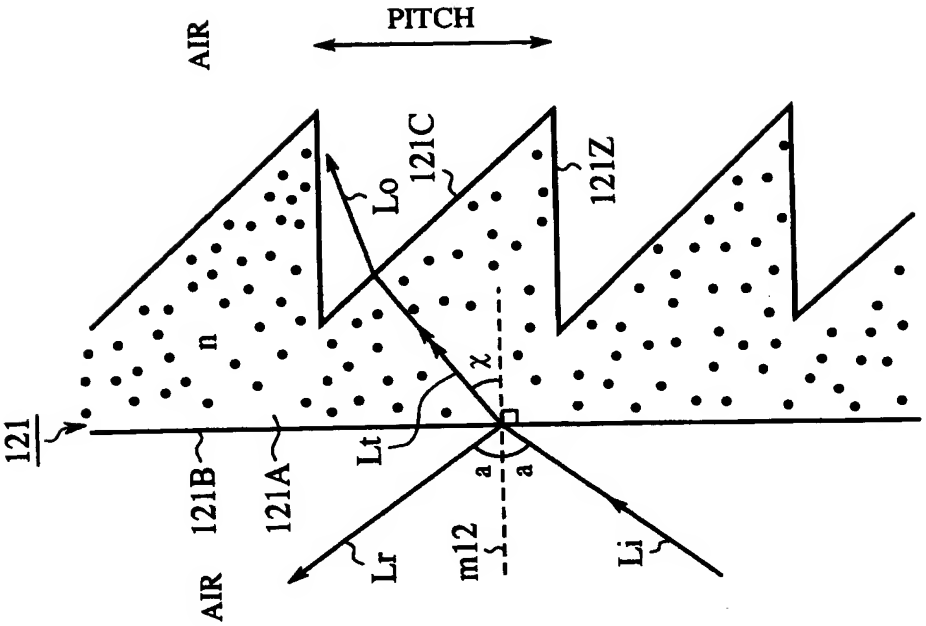

AIR
PITCH
Lo
121C
121Z
n
χ
121
121B
121A
Lt
a
a
AIR
Lr
m12
Li

FIG.3A

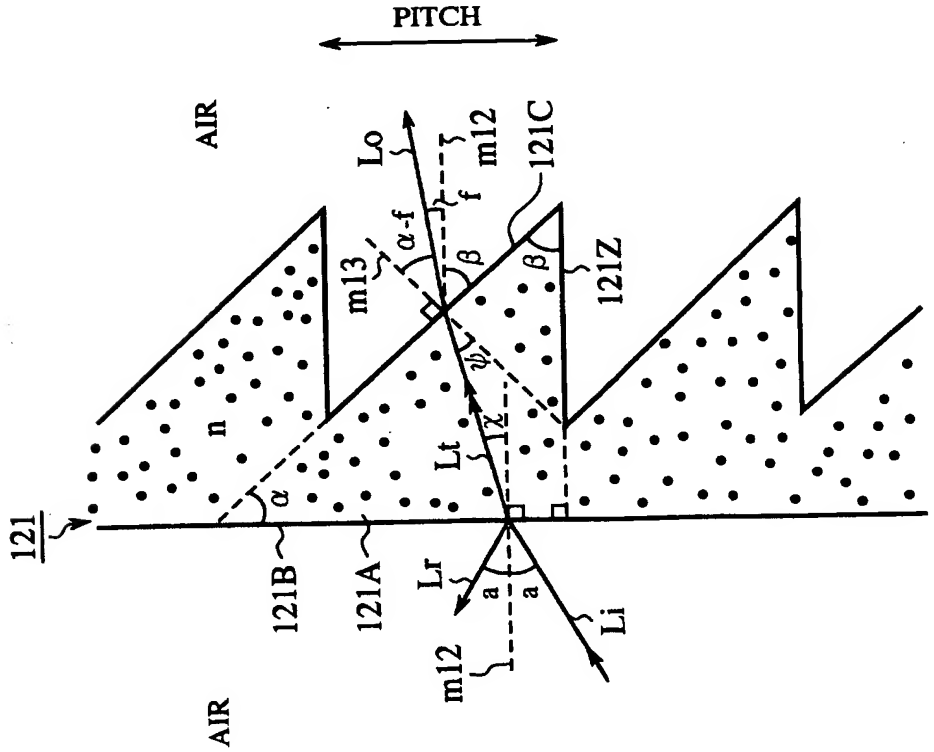

PITCH
AIR
Lo
m12
121C
m13
α-f
f
β
β
121Z
ψ
χ
n
α
Lt
121
121B
121A
Lr
a
a
Li
m12
AIR

FIG.4A

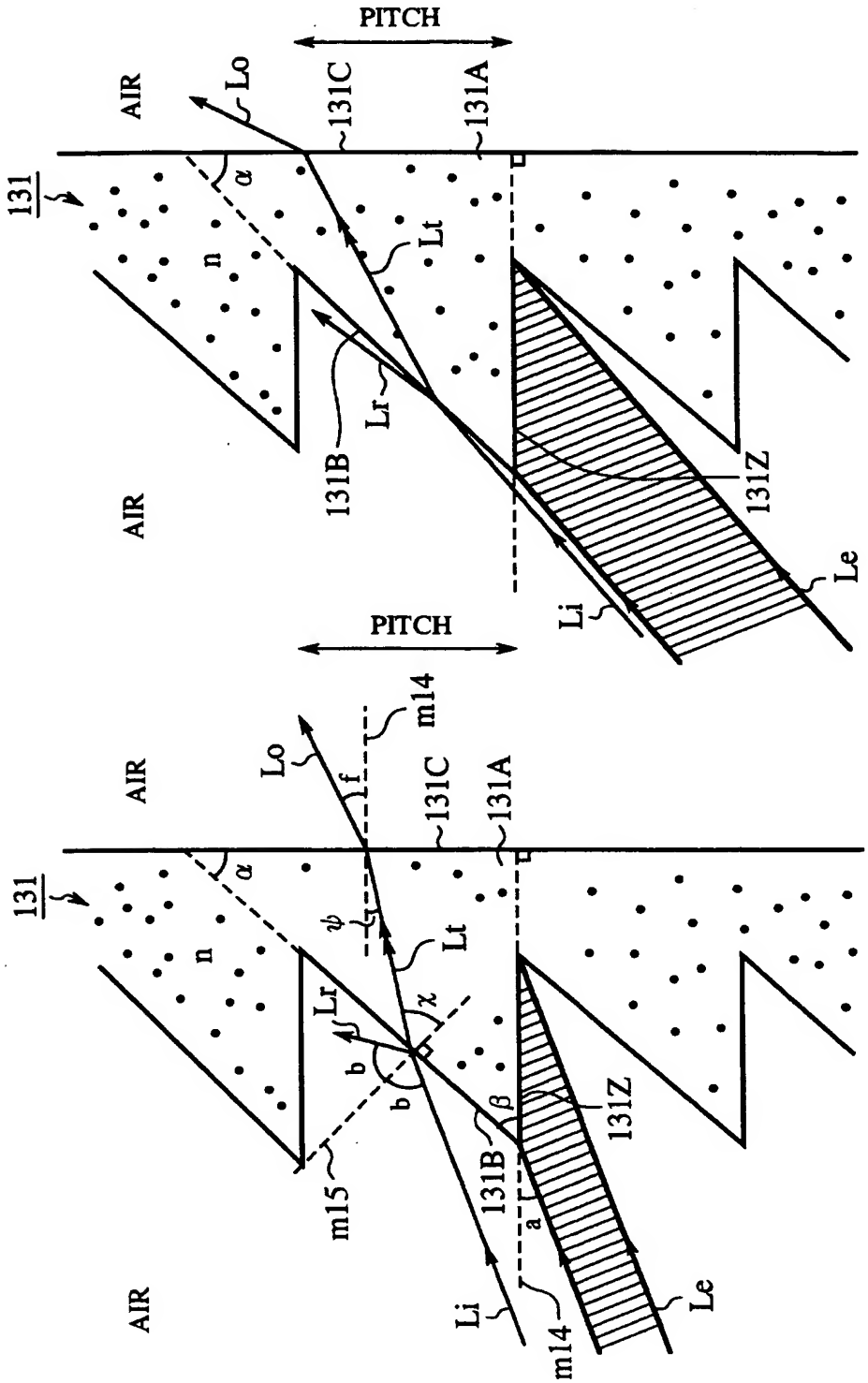

AIR
AIR
131
n
α
Lo
f
m14
131C
131A
Lt
ψ
χ
Lr
b
b
β
131B
131Z
m15
a
Li
Le
m14

FIG.4B

PITCH
AIR
Lo
131C
131A
131
α
n
Lt
Lr
131B
AIR
131Z
Li
Le

FIG.5B

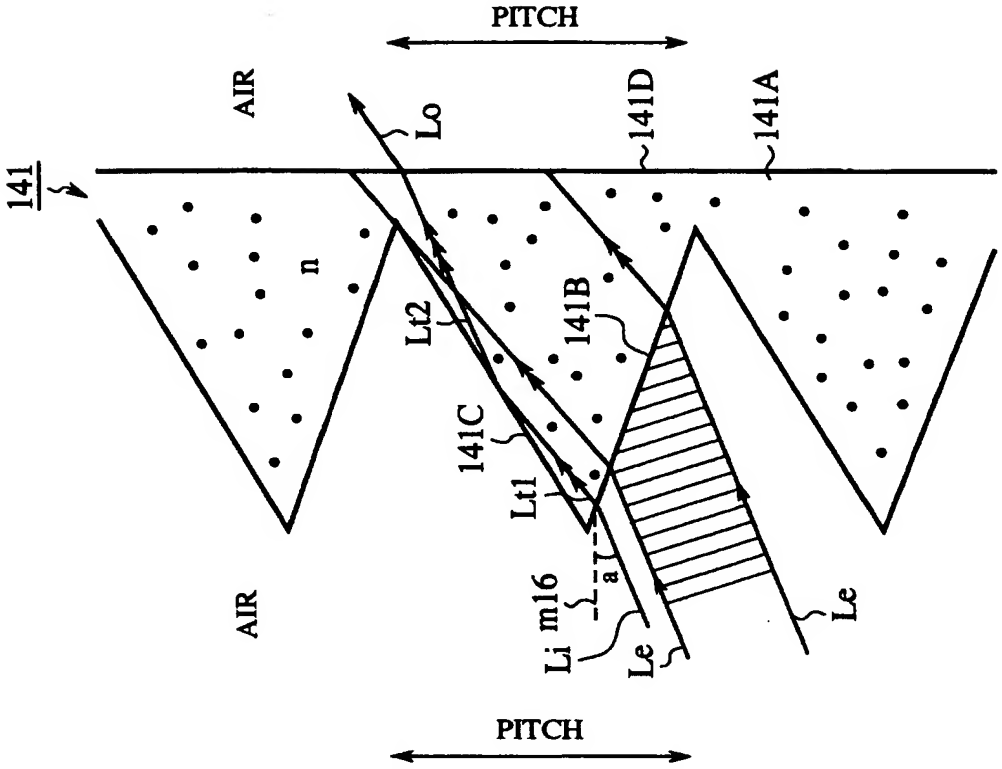

PITCH
AIR
Lo
141D
141A
141
n
Lt2
141B
141C
Lt1
a
Li
m16
Le
AIR
Le

FIG.5A

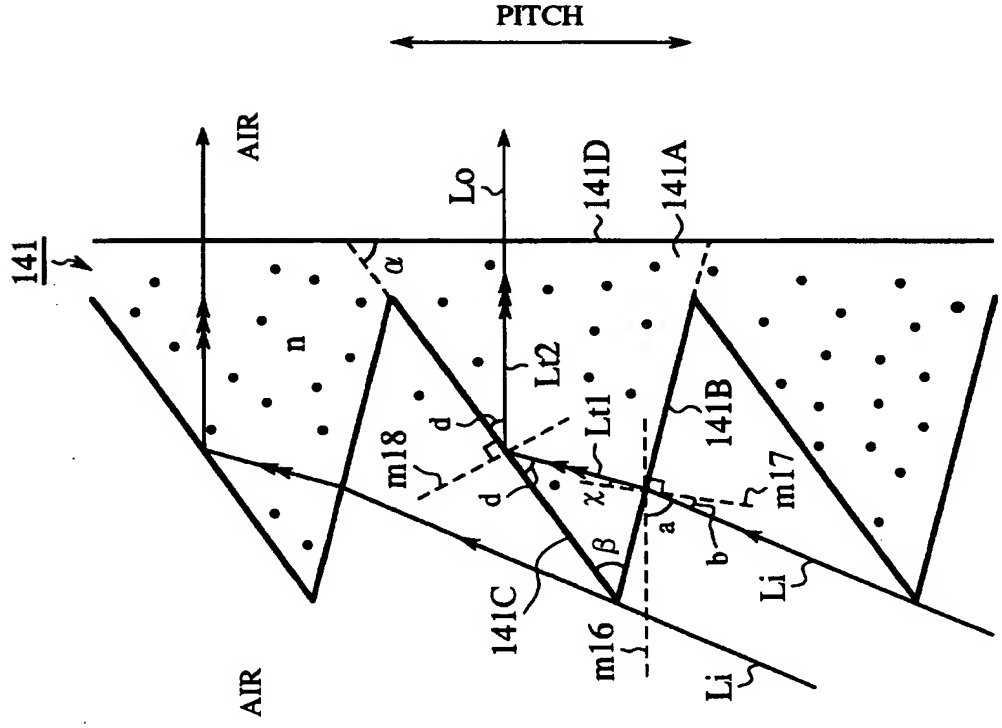
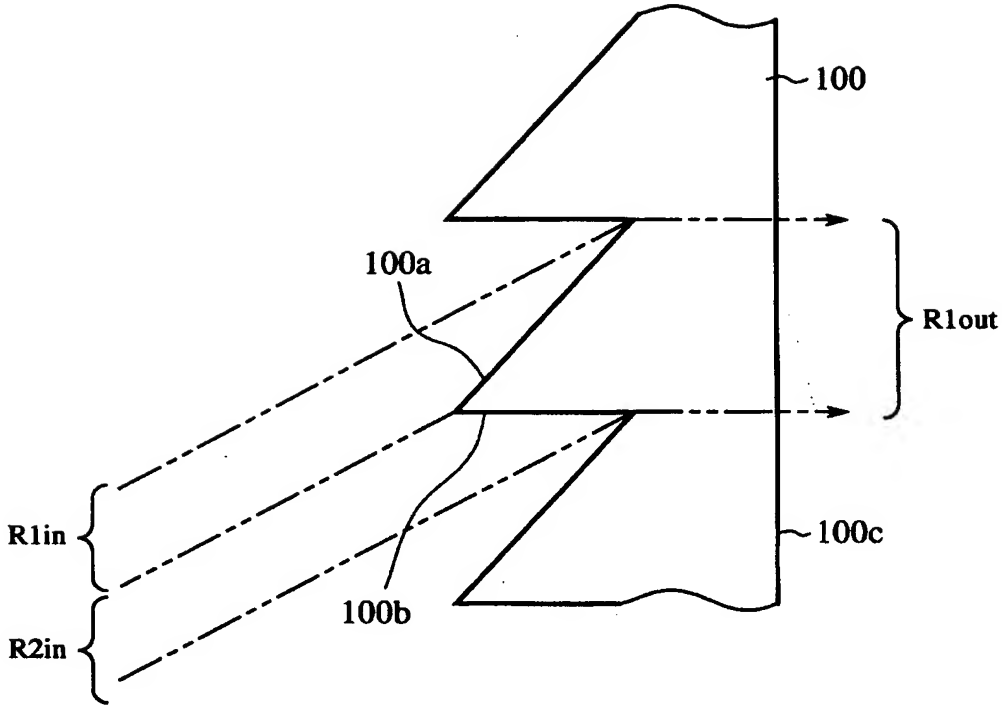

PITCH
AIR
Lo
141D
141A
141
α
n
Lt2
Lt1
141B
m18
d
d
m17
β
a
b
Li
141C
m16
Li
AIR

FIG.6



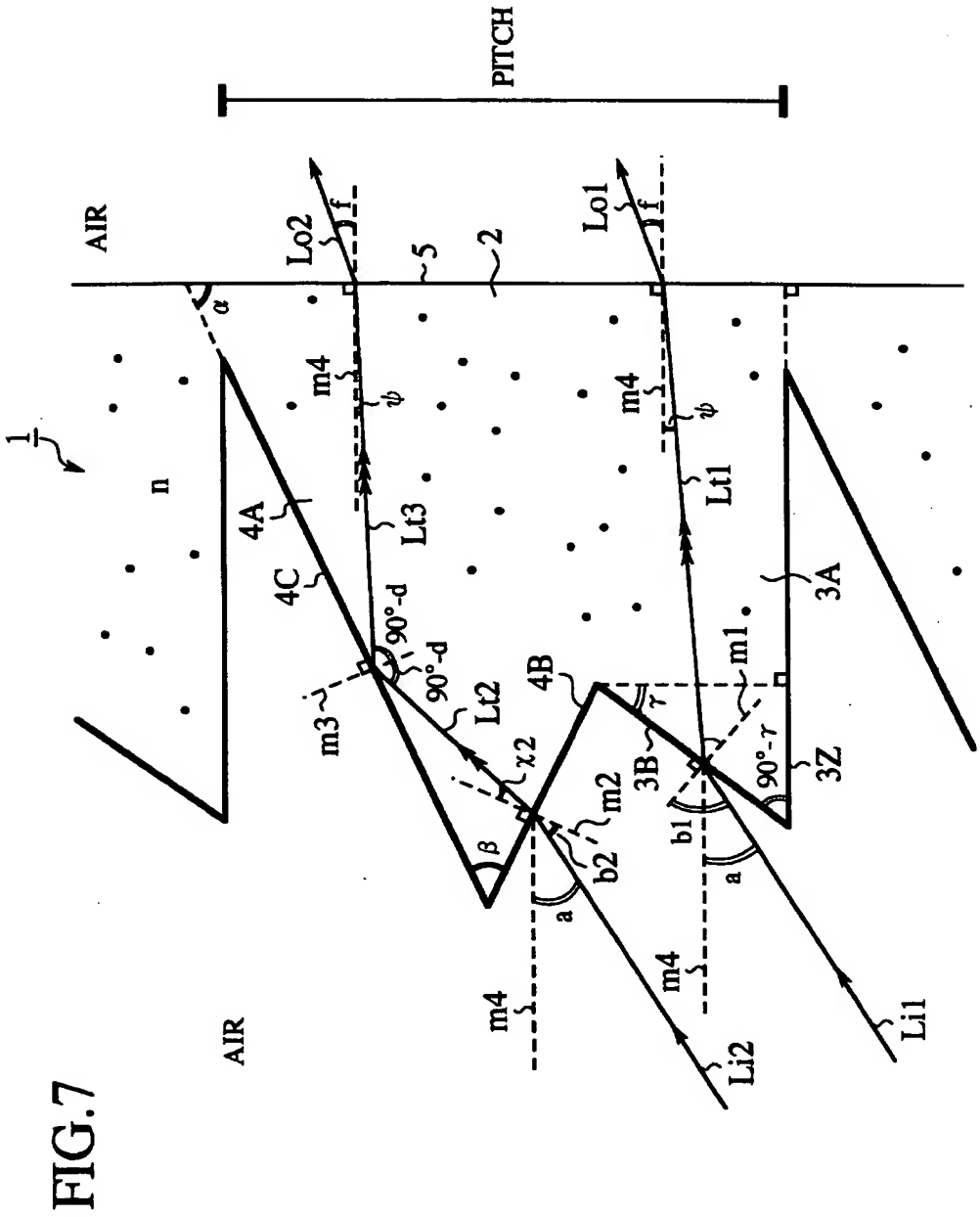

PITCH
AIR
AIR
Lo2
Lo1
f
f
5
2
α
m4
ψ
m4
ψ
1
n
4A
4C
Lt3
Lt1
3A
90°-d
90°-d
m3
Lt2
4B
m1
χ2
γ
3B
m2
90°-γ
3Z
β
b2
b1
a
a
m4
m4
Li2
Li1

FIG.7

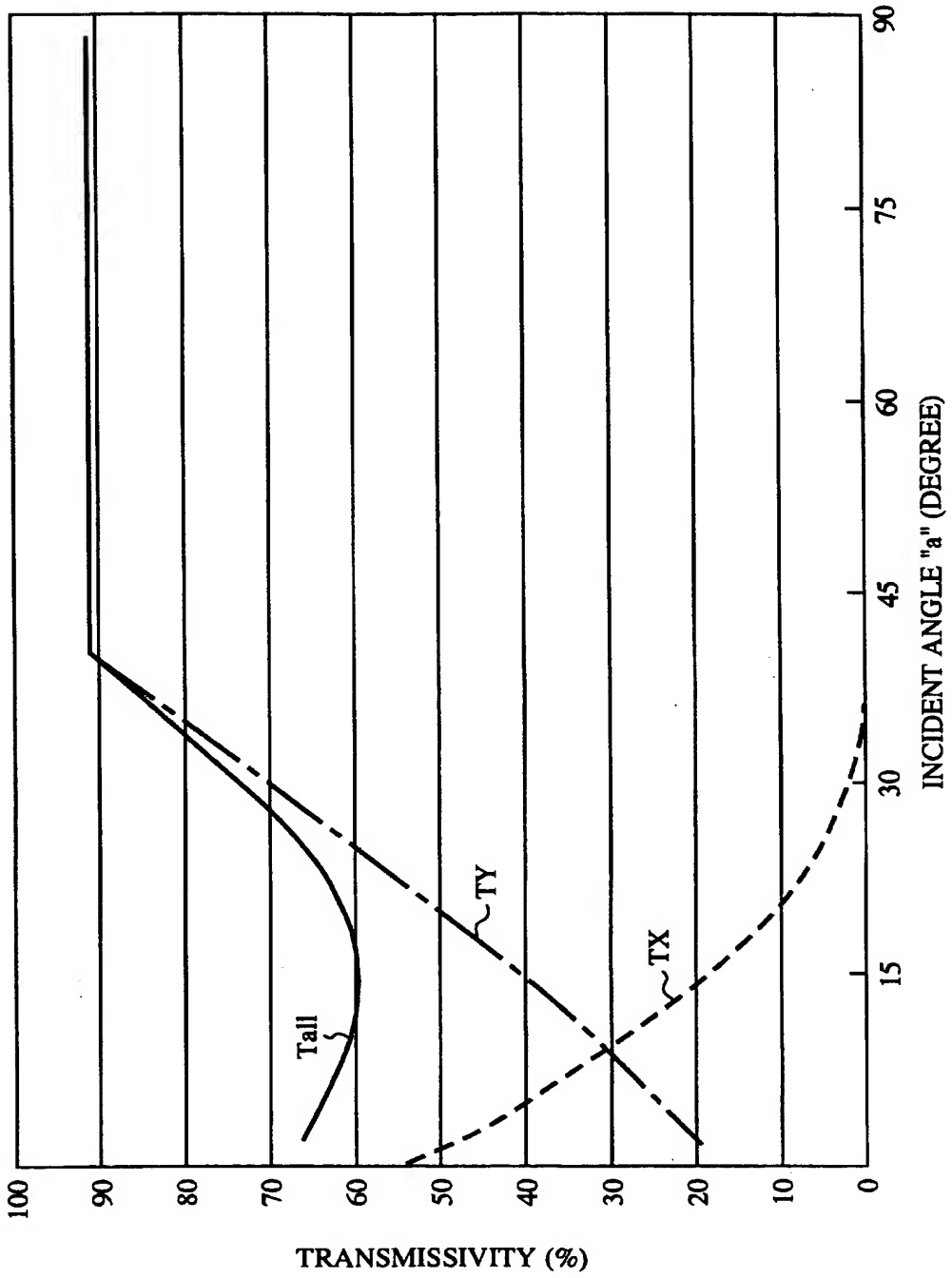

100
90
80
70
60
50
40
30
20
10
0
TRANSMISSIVITY (%)
Tall
TY
TX
0
15
30
45
60
75
90
INCIDENT ANGLE "a" (DEGREE)

FIG.8

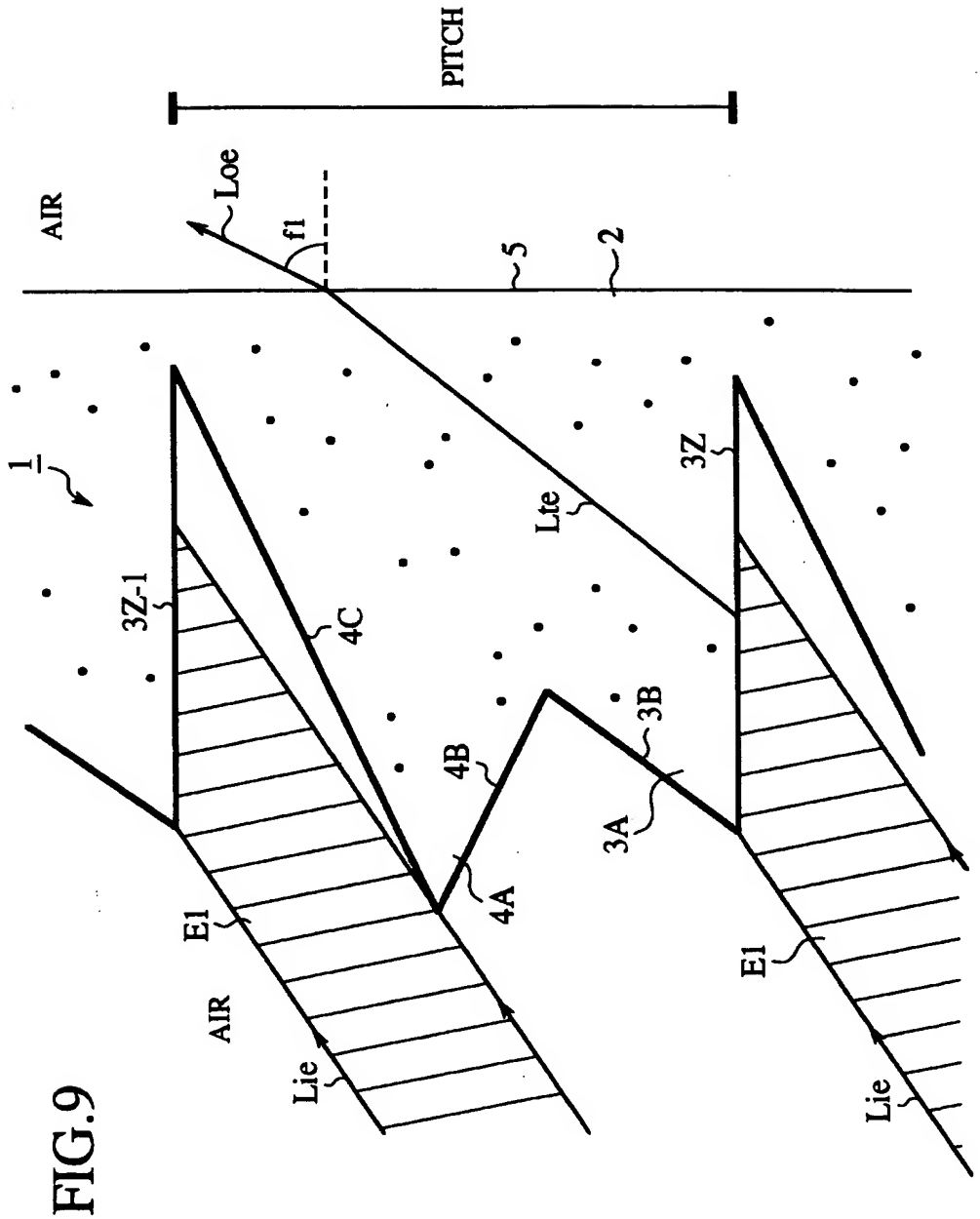


FIG.9

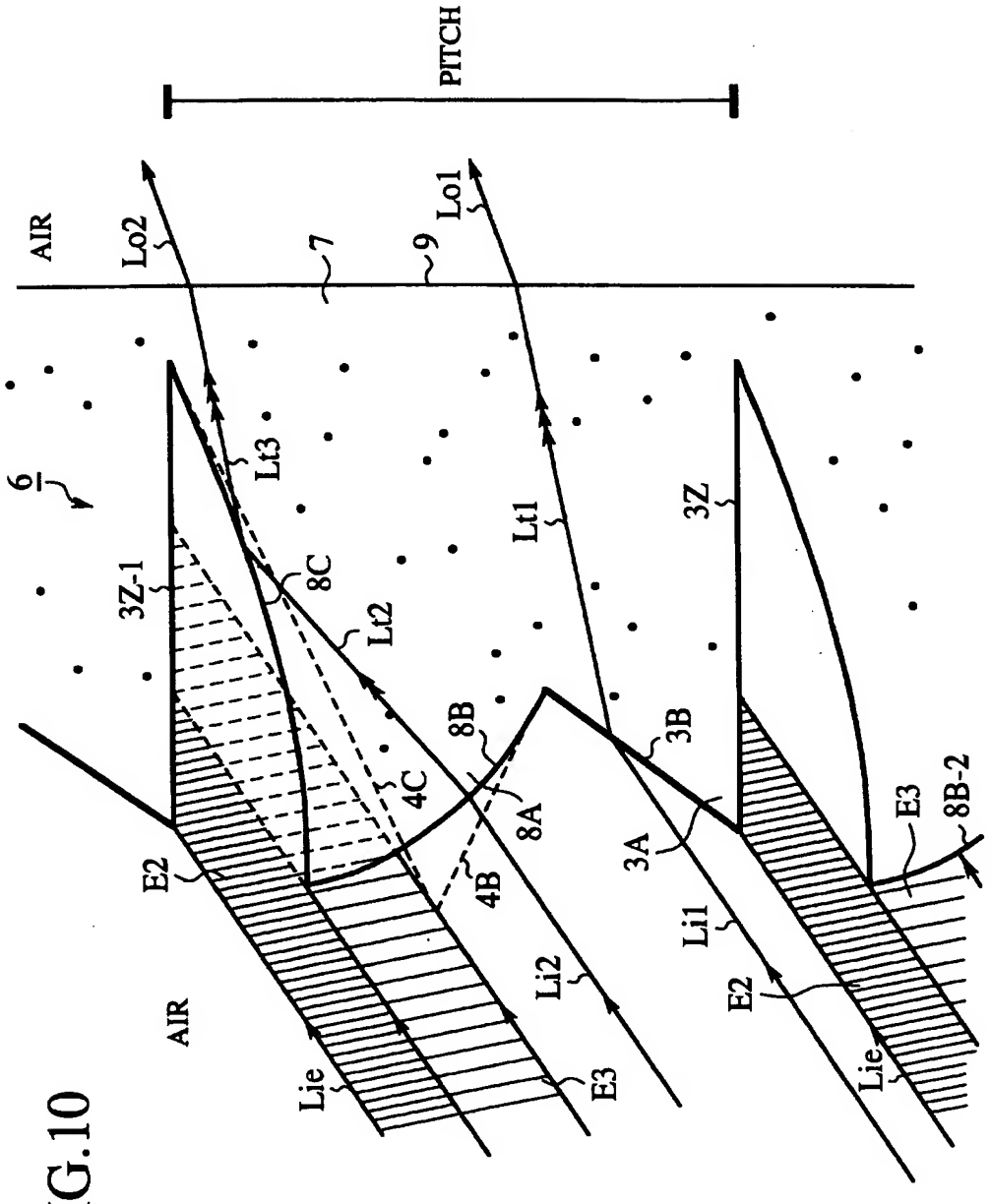

PITCH
AIR
Lo2
7
9
Lo1
6
3Z-1
Lt3
8C
Lt2
Lt1
3Z
8B
3B
4C
8A
4B
3A
E2
AIR
Li2
Li1
E3
8B-2
E2
Lie
Lie
E3

FIG.10

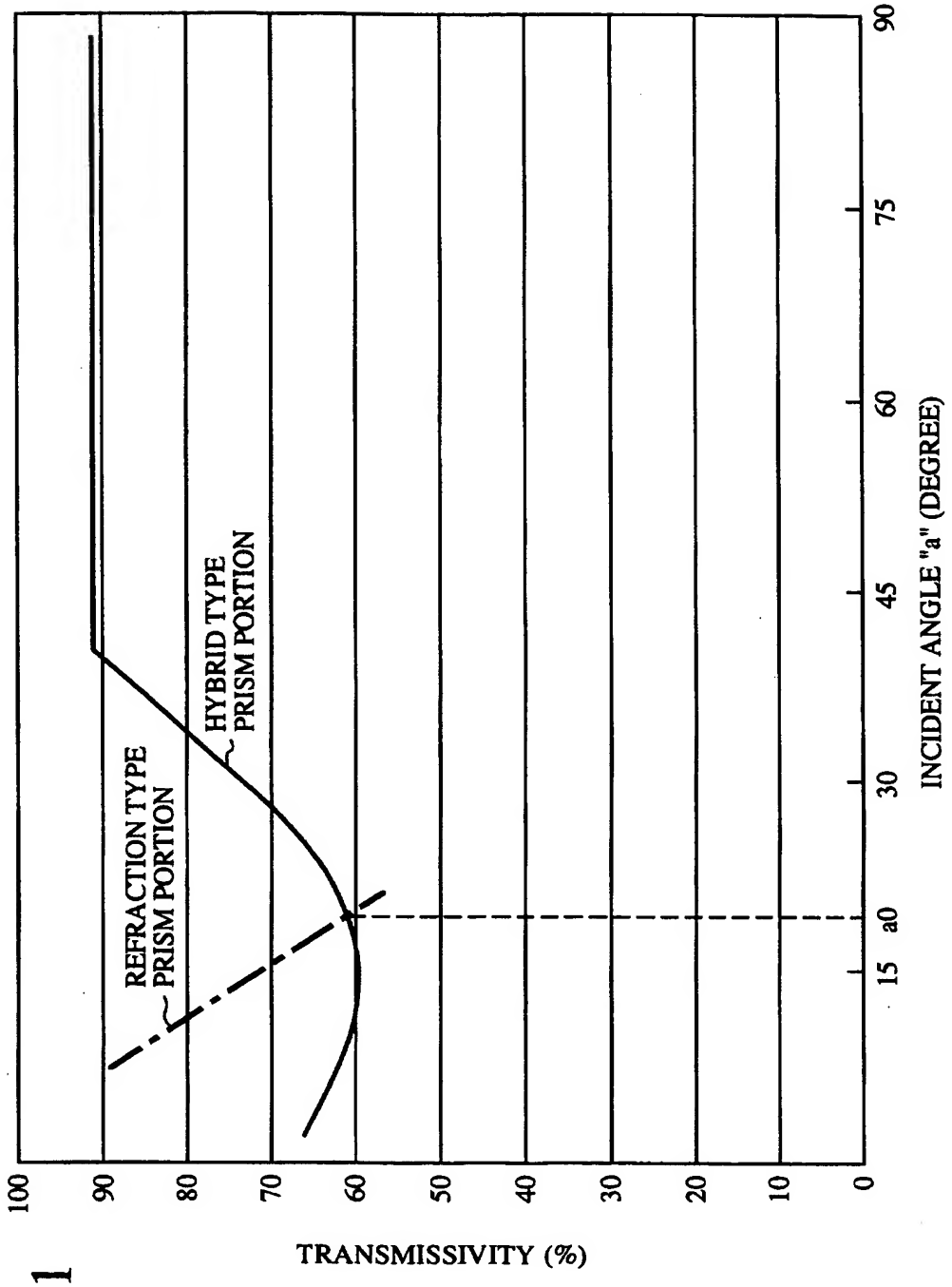

REFRACTION TYPE PRISM PORTION
HYBRID TYPE PRISM PORTION
100
90
80
70
60
50
40
30
20
10
0
TRANSMISSIVITY (%)
15
a0
30
45
60
75
90
INCIDENT ANGLE "a" (DEGREE)

FIG.11

FIG.12

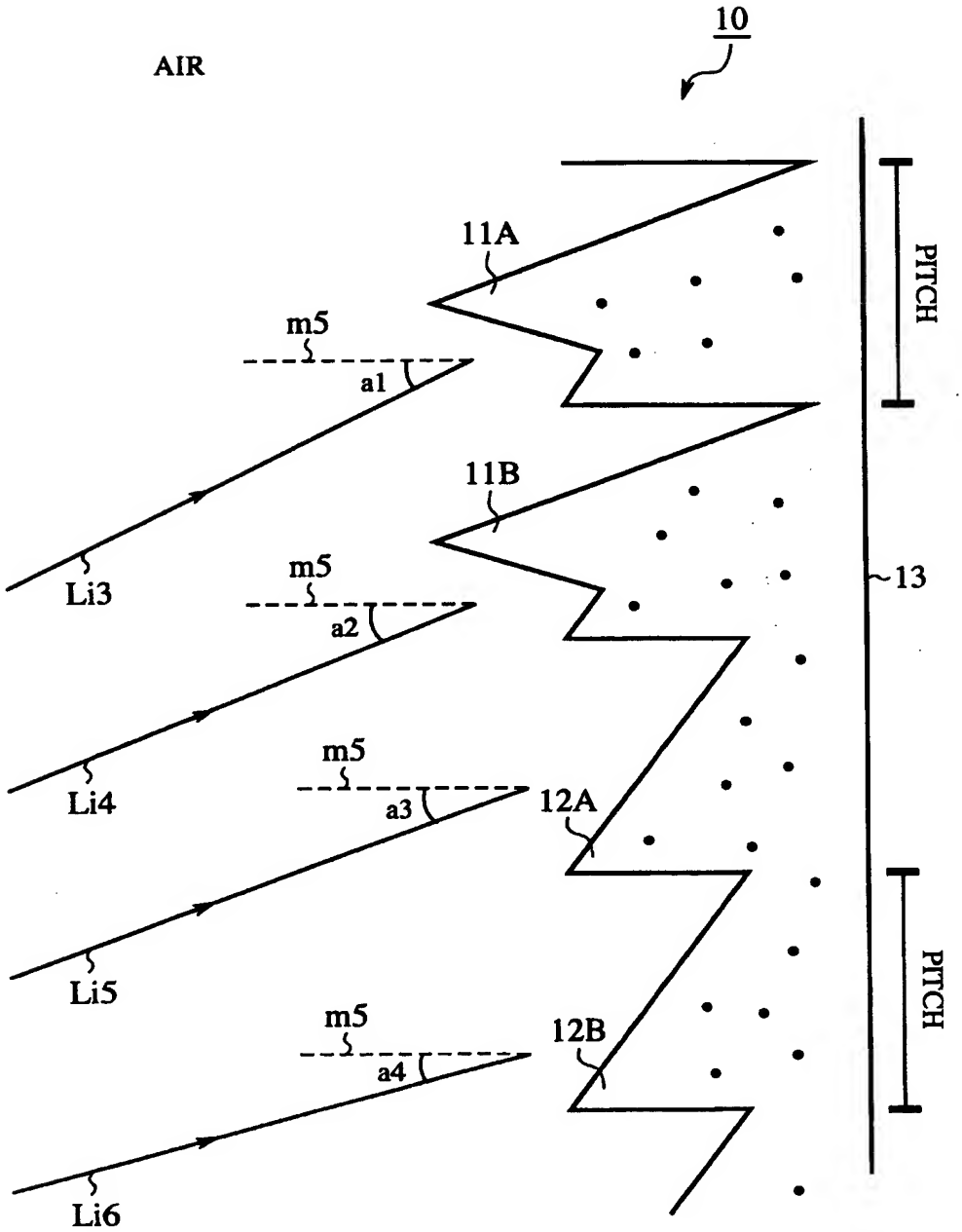

10
AIR
11A
m5
a1
PITCH
11B
Li3
m5
a2
13
Li4
m5
a3
12A
Li5
m5
a4
12B
PITCH
Li6

FIG.13

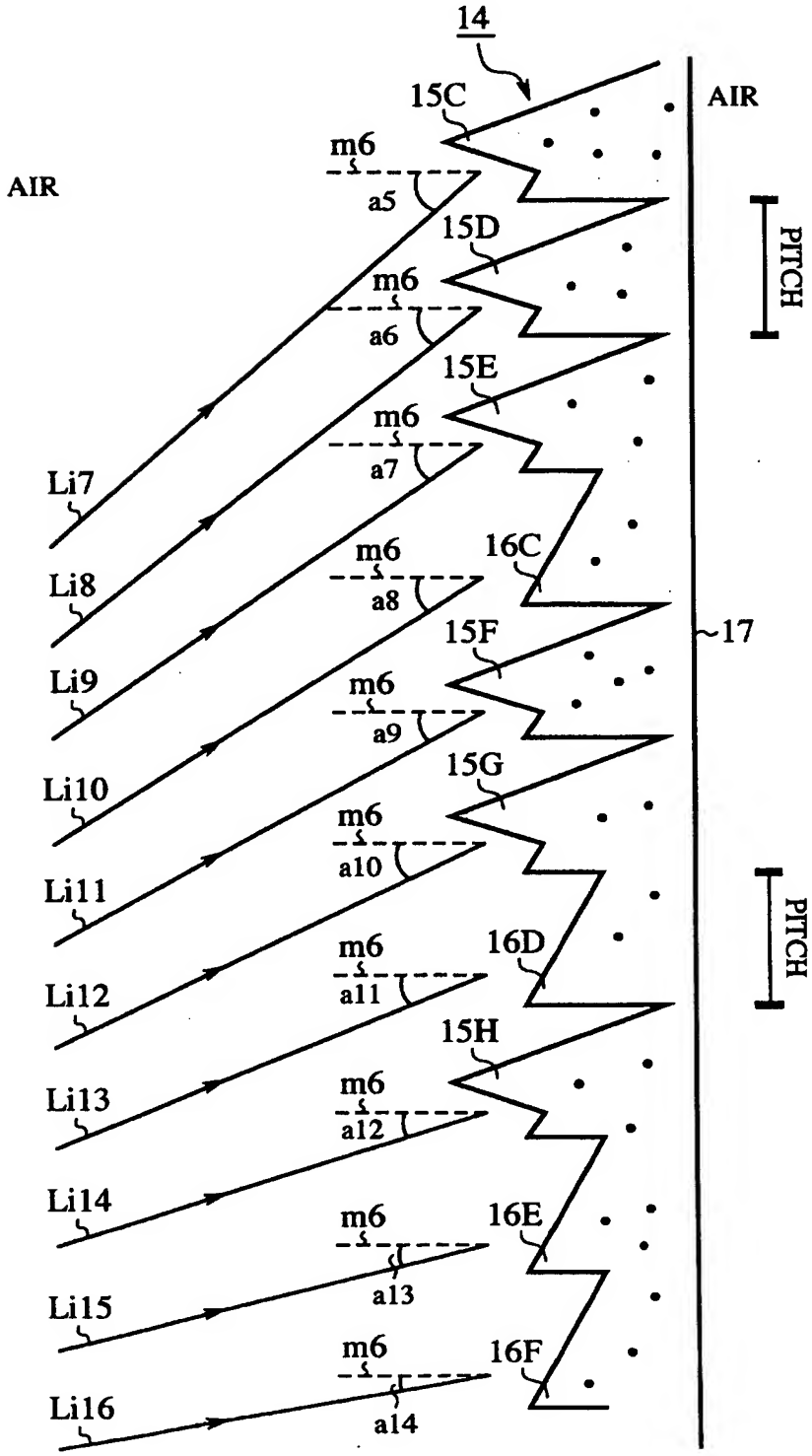
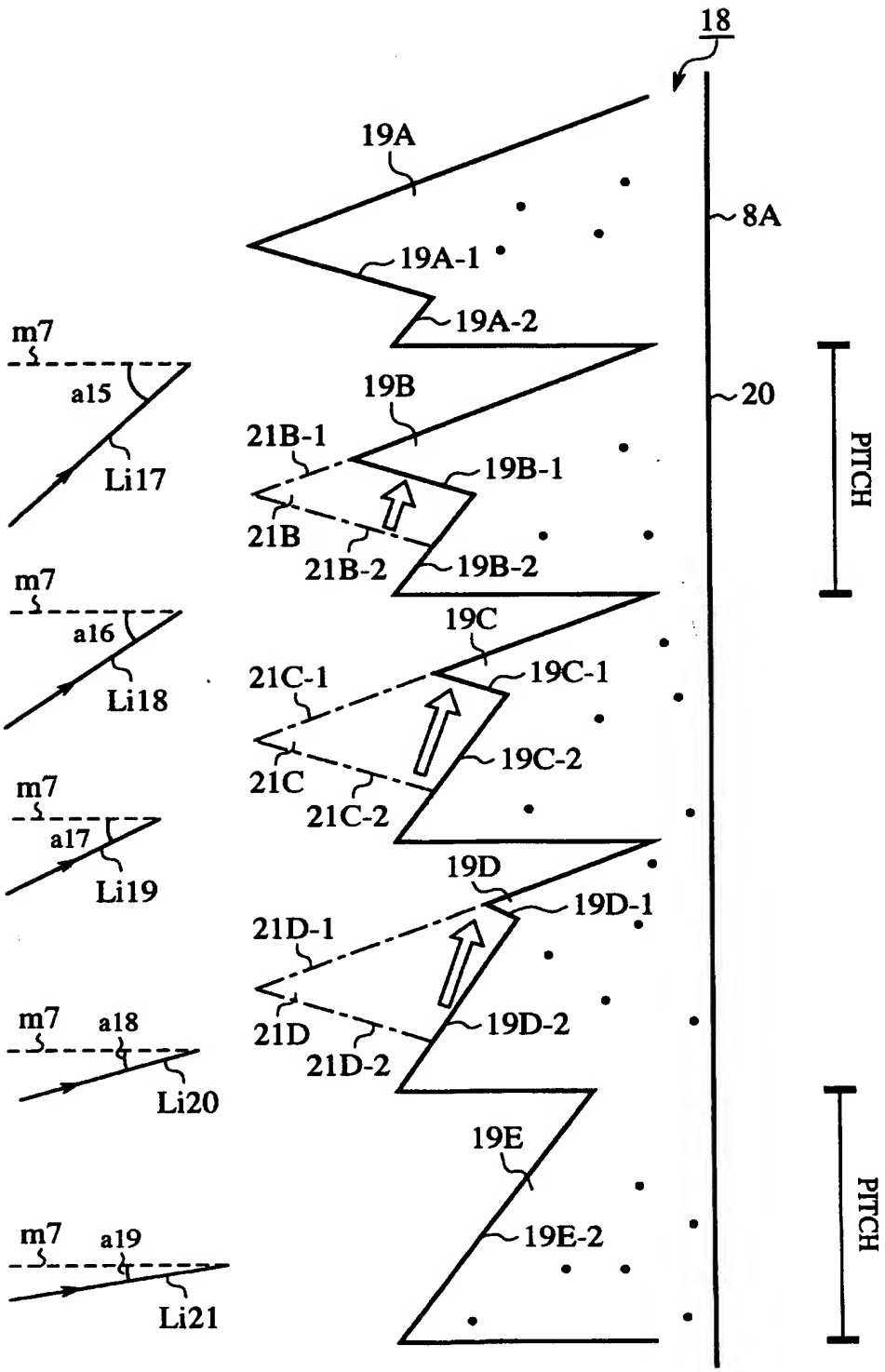

14
15C
AIR
m6
a5
AIR
15D
m6
a6
PITCH
15E
m6
a7
Li7
Li8
m6
a8
16C
Li9
15F
m6
a9
~17
Li10
15G
m6
a10
Li11
PITCH
m6
a11
16D
Li12
15H
Li13
m6
a12
Li14
m6
a13
16E
Li15
m6
a14
16F
Li16

FIG.14


18
19A
8A
19A-1
19A-2
m7
a15
Li17
19B
20
21B-1
19B-1
21B
21B-2
19B-2
PITCH
m7
a16
Li18
19C
21C-1
19C-1
19C-2
21C
21C-2
m7
a17
Li19
19D
19D-1
21D-1
m7
a18
21D
19D-2
21D-2
Li20
19E
19E-2
m7
a19
Li21
PITCH

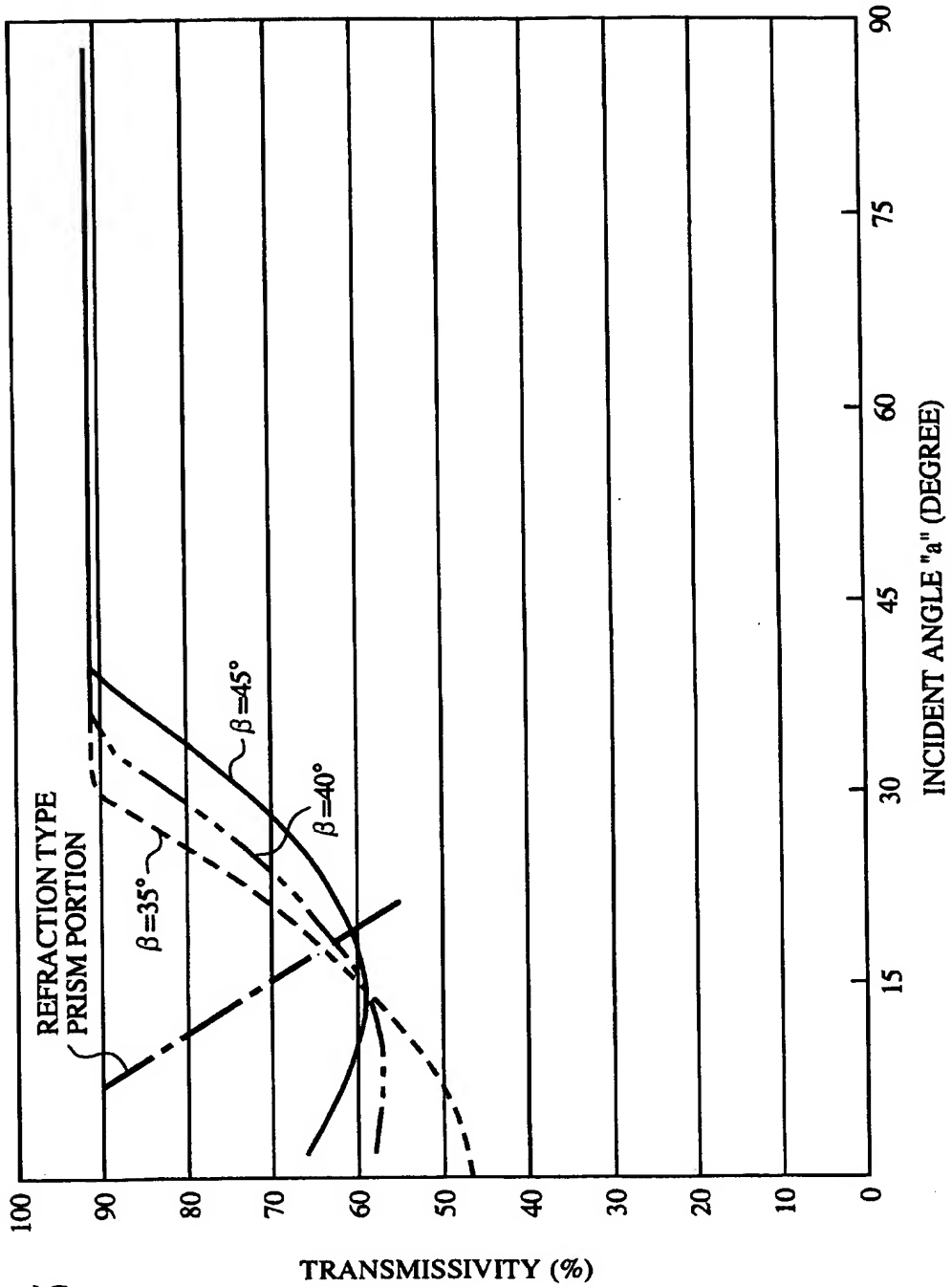

REFRACTION TYPE
PRISM PORTION
β=35°
β=40°
β=45°
100
90
80
70
60
50
40
30
20
10
0
TRANSMISSIVITY (%)
15
30
45
60
75
90
INCIDENT ANGLE "a" (DEGREE)

FIG.15

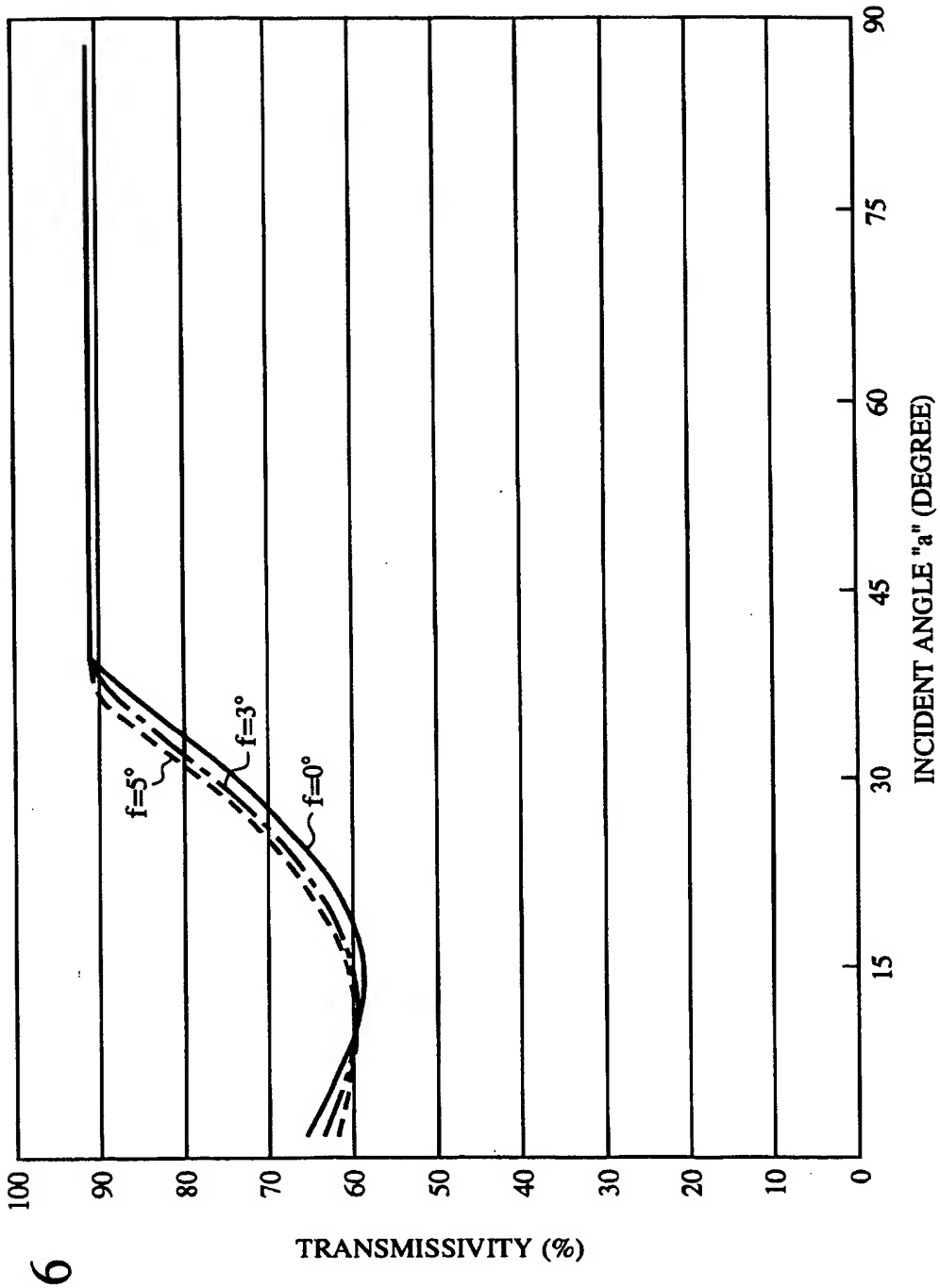

f=5°
f=3°
f=0°
100
90
80
70
60
50
40
30
20
10
0
TRANSMISSIVITY (%)
15
30
45
60
75
90
INCIDENT ANGLE "a" (DEGREE)

FIG.16

FIG.17A

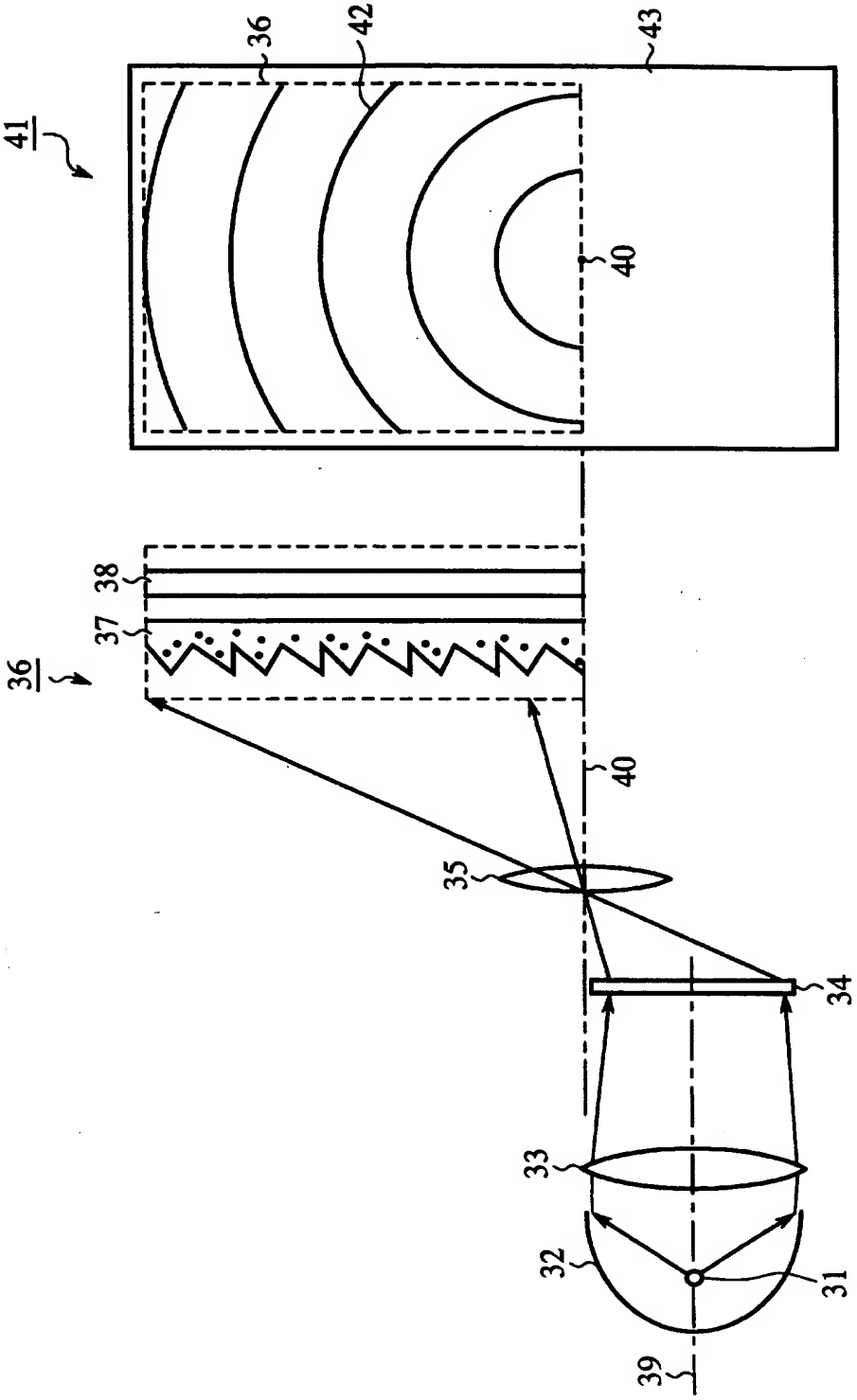


FIG.17B

FIG.18A

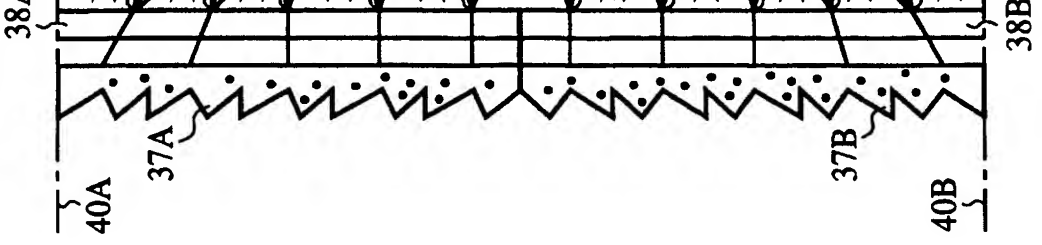


FIG.18B

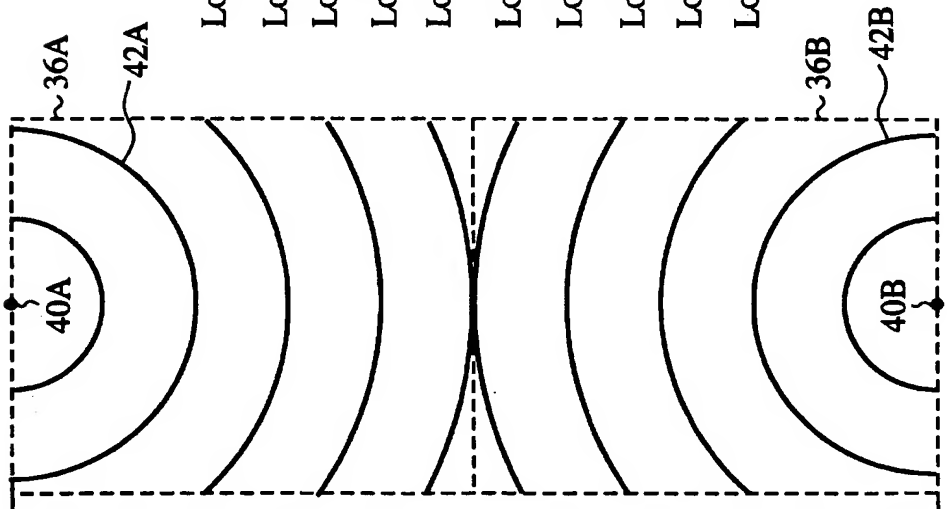
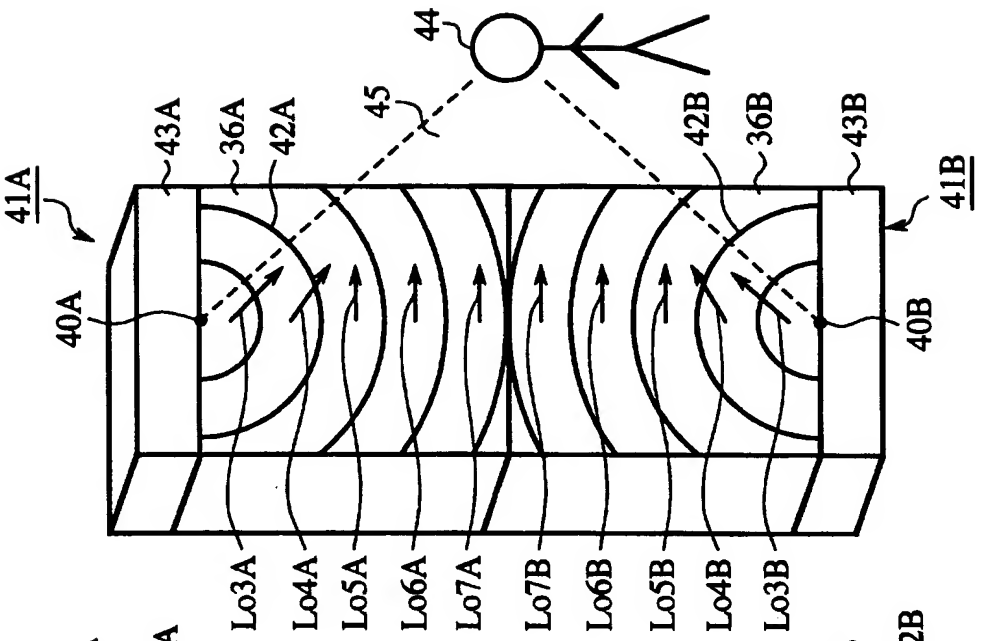


FIG.18C



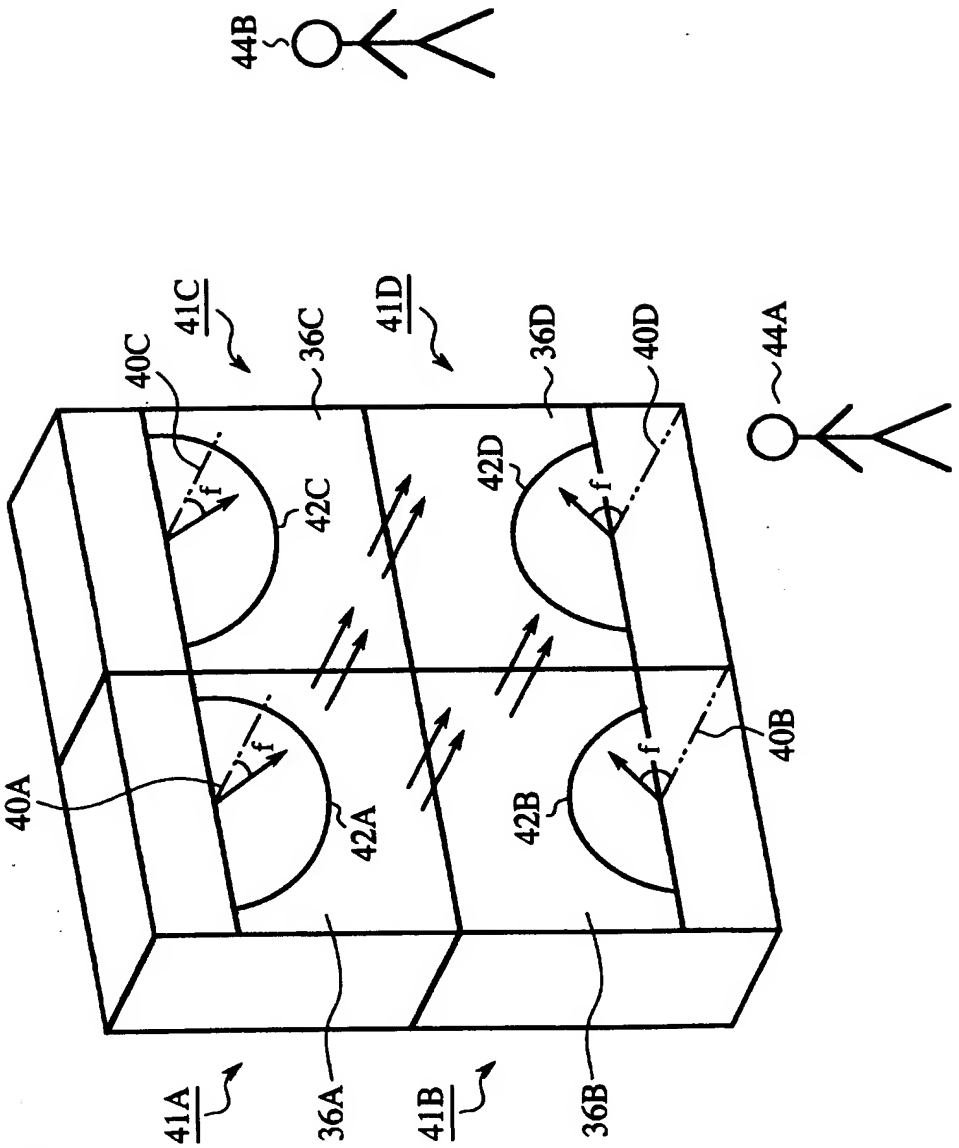

44B
41C
40C
36C
41D
36D
40D
44A
42C
42D
f
40A
42A
42B
40B
41A
36A
41B
36B

FIG.19

FIG.20

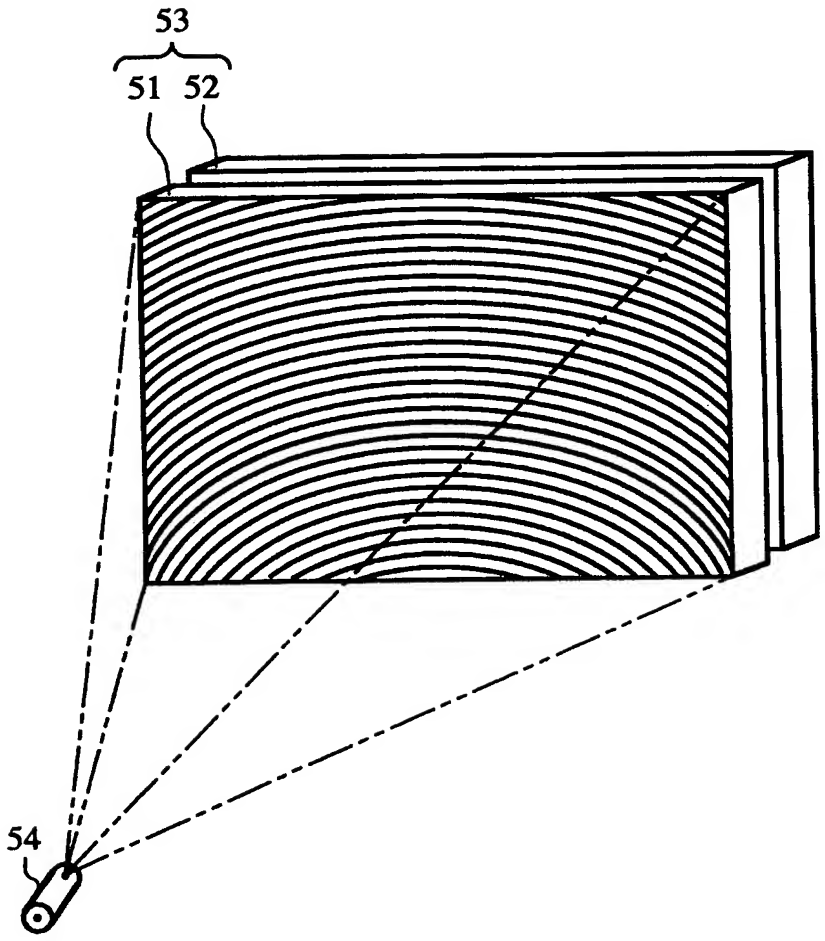


FIG.21

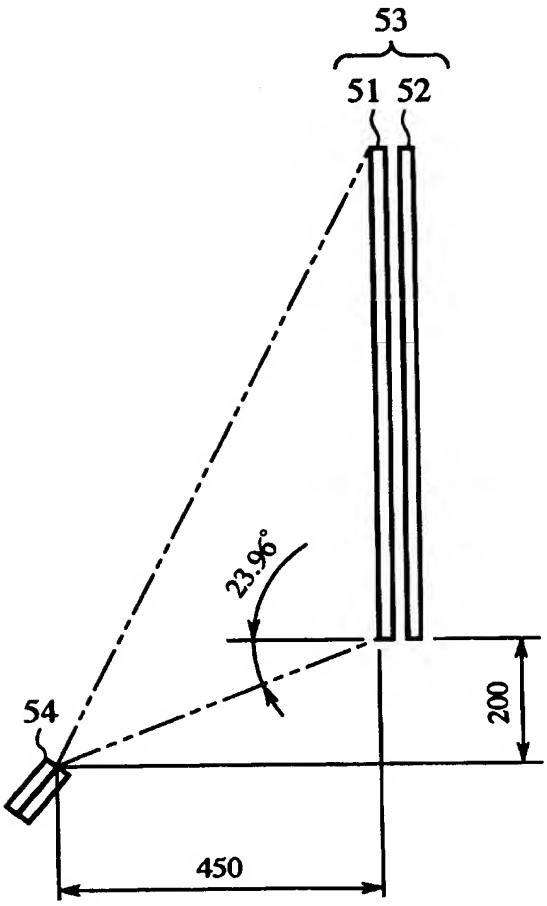


FIG.22

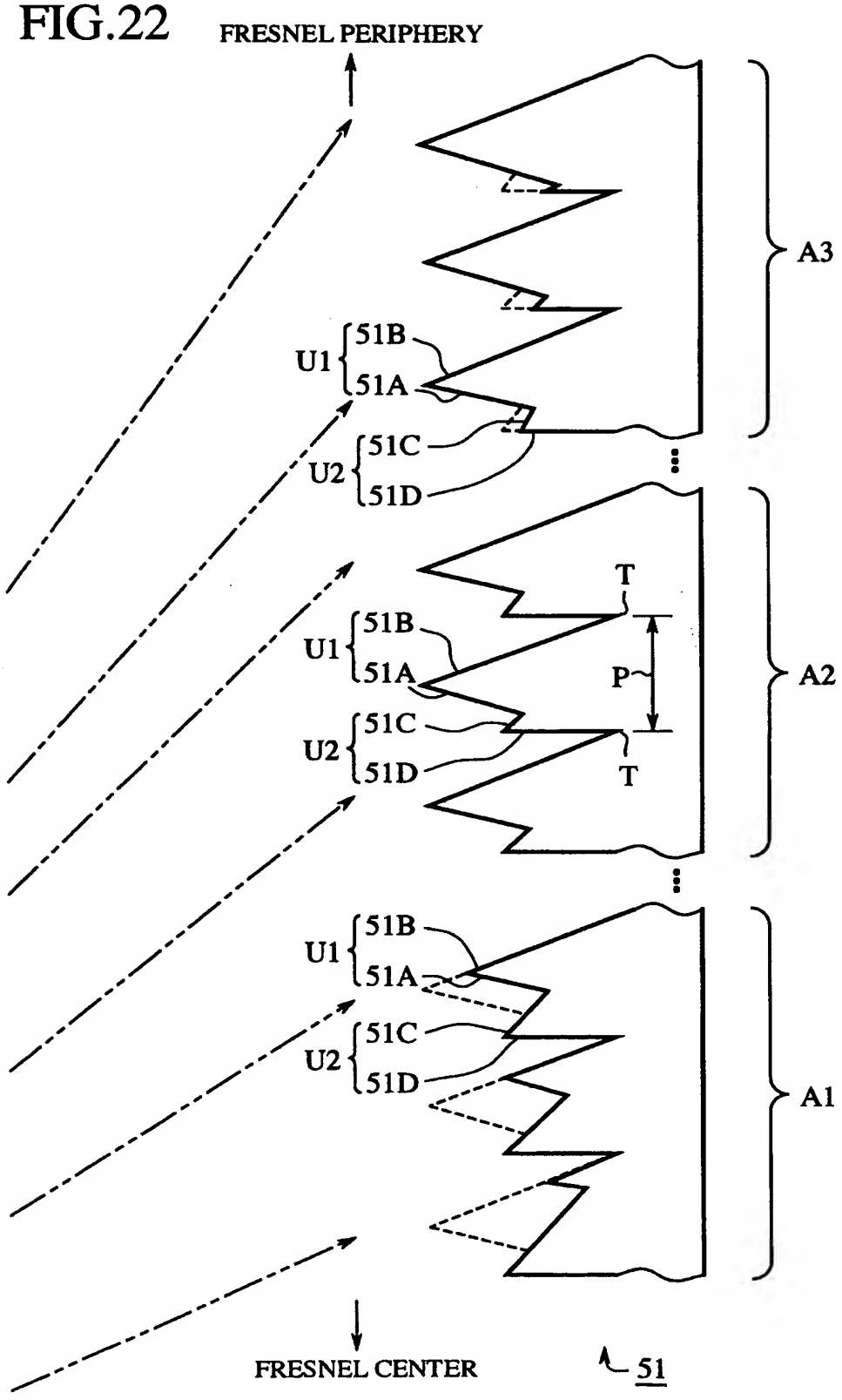

FRESNEL PERIPHERY
A3
U1
51B
51A
U2
51C
51D
T
P
A2
FRESNEL CENTER
51

FIG.23A

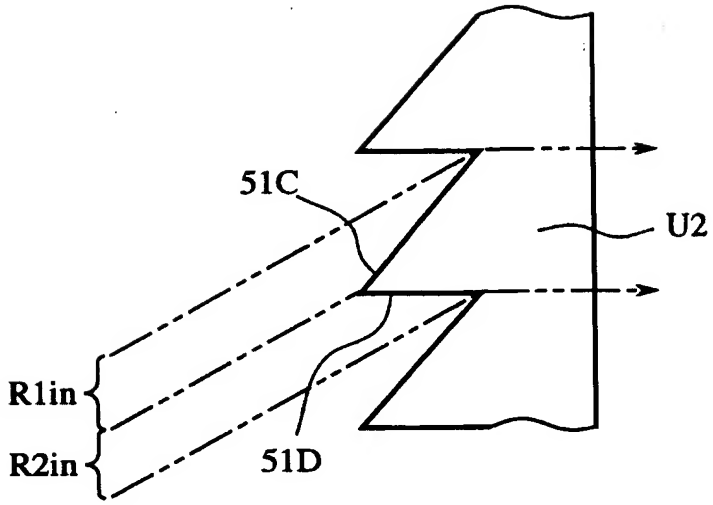


FIG.23B

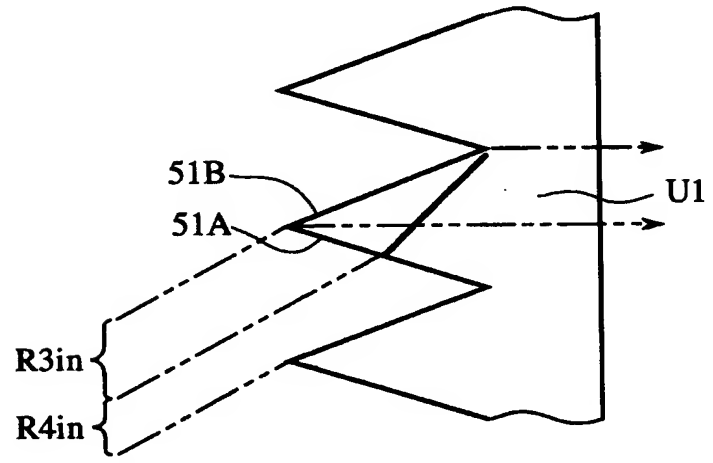


FIG.23C

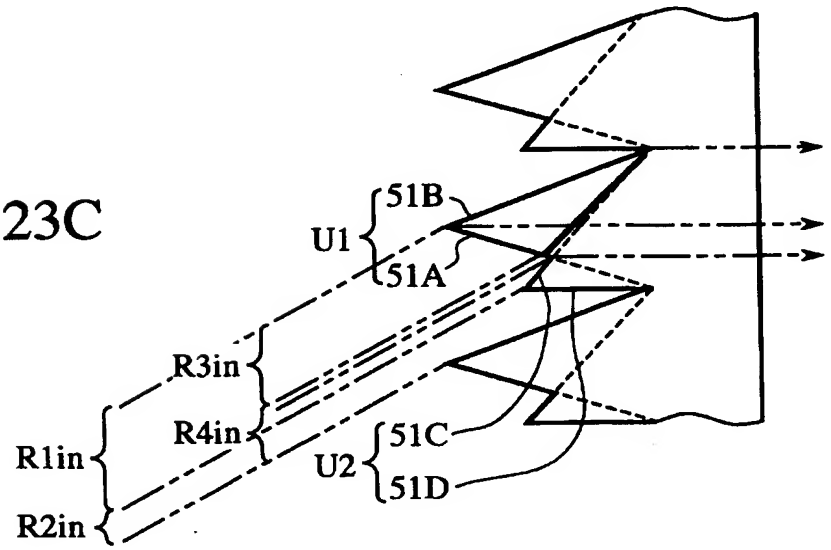


FIG.24A

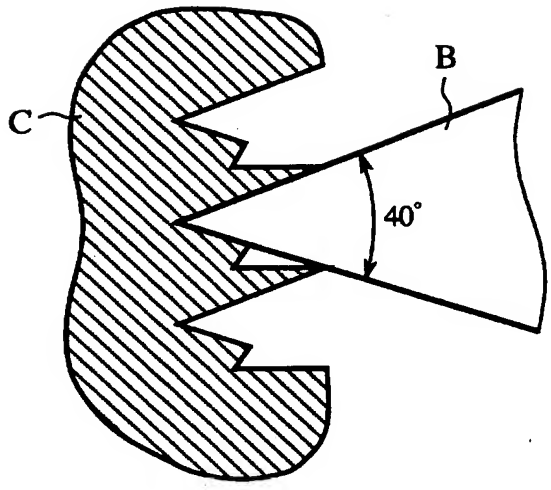


FIG.24B

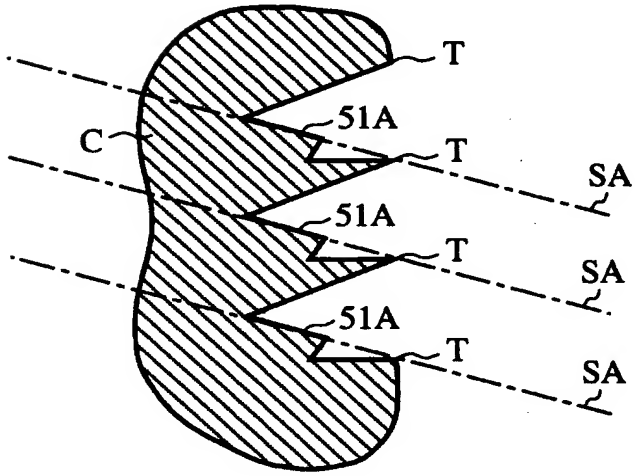


FIG.24C

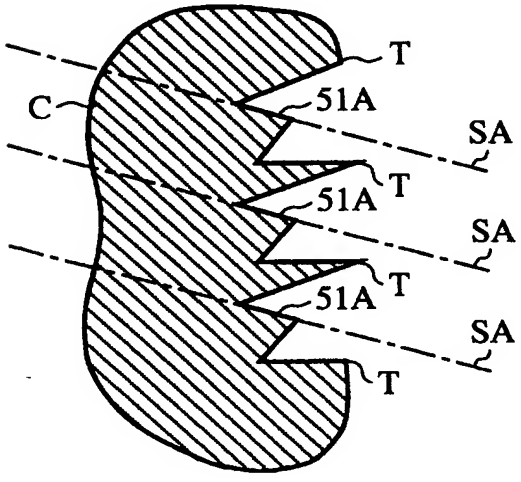


FIG.25A

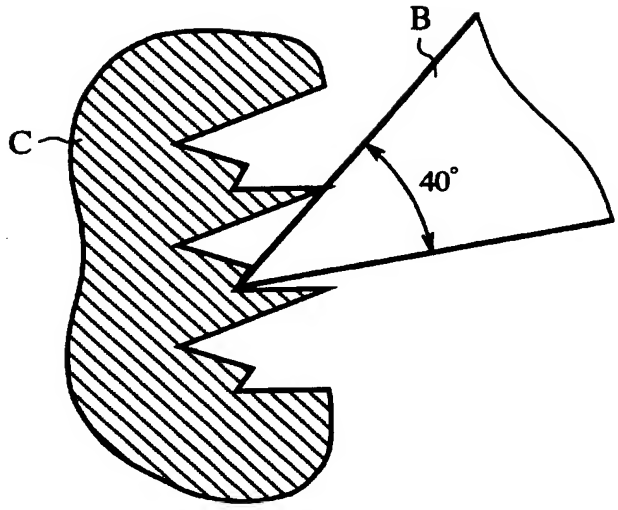


FIG.25B

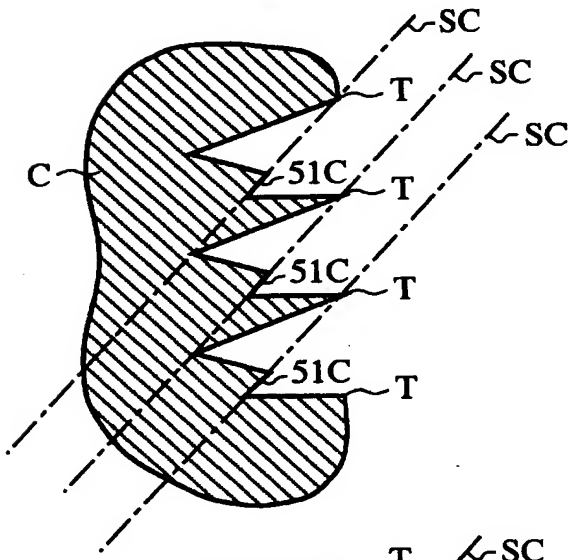


FIG.25C

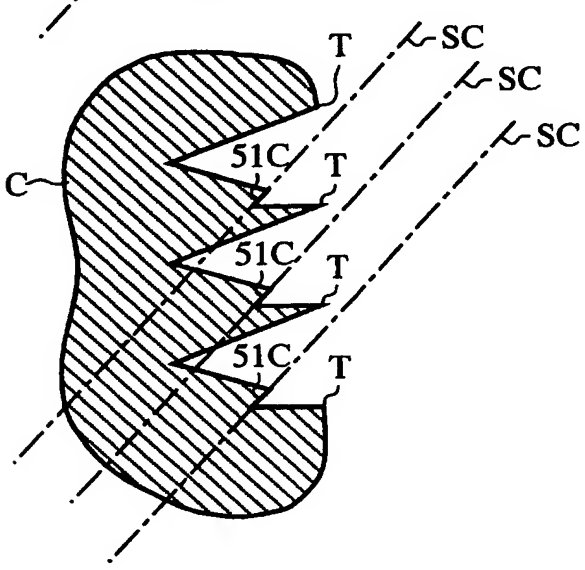
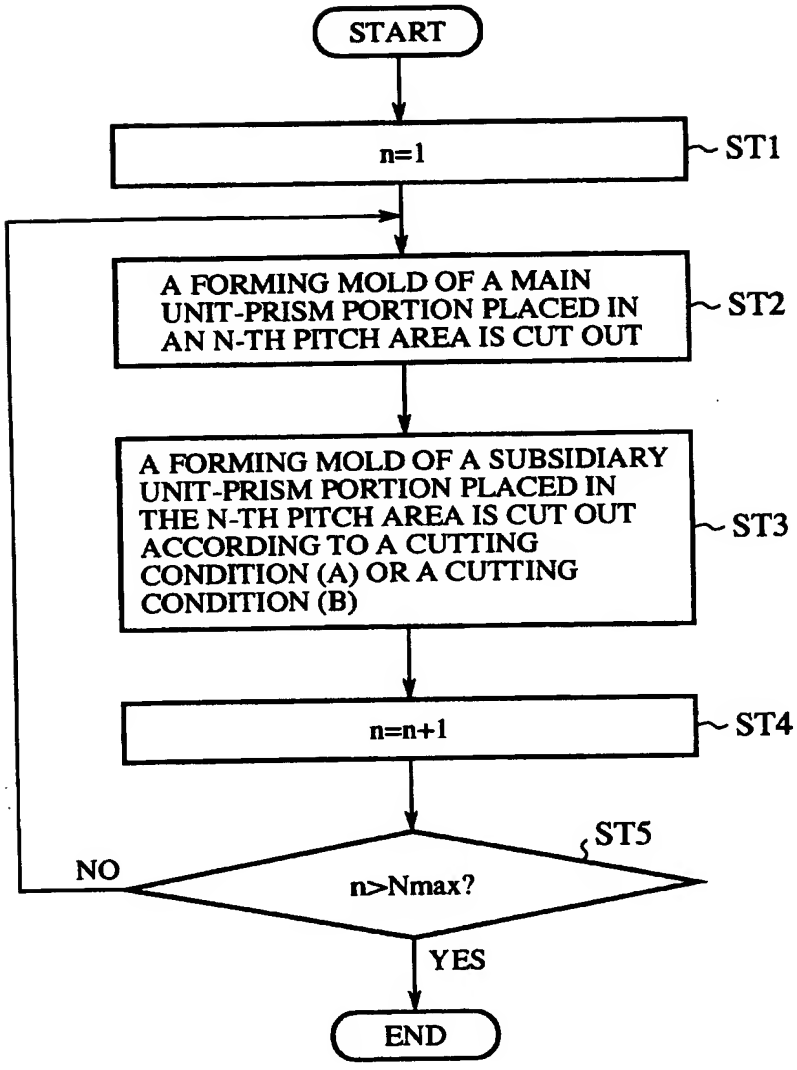


FIG.26


START
n=1
ST1
A FORMING MOLD OF A MAIN UNIT-PRISM PORTION PLACED IN AN N-TH PITCH AREA IS CUT OUT
ST2
A FORMING MOLD OF A SUBSIDIARY UNIT-PRISM PORTION PLACED IN THE N-TH PITCH AREA IS CUT OUT ACCORDING TO A CUTTING CONDITION (A) OR A CUTTING CONDITION (B)
ST3
n=n+1
ST4
ST5
NO
n>Nmax?
YES
END

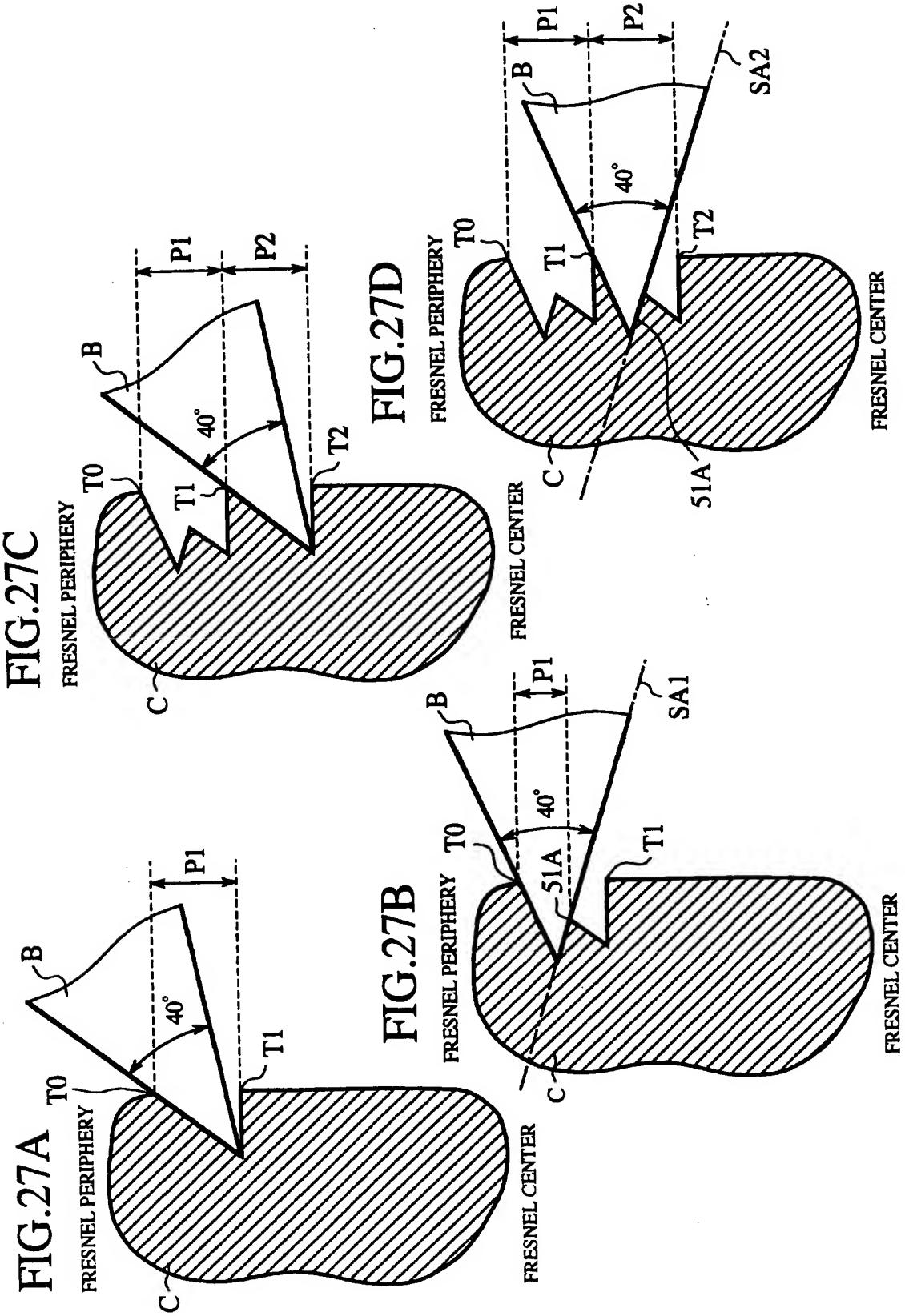


FIG.27A
FRESNEL PERIPHERY
FRESNEL CENTER
T0
T1
P1
B
40°
C
FIG.27B
FRESNEL PERIPHERY
FRESNEL CENTER
T0
T1
P1
B
40°
51A
SA1
C
FIG.27C
FRESNEL PERIPHERY
FRESNEL CENTER
T0
T1
T2
P1
P2
B
40°
C
FIG.27D
FRESNEL PERIPHERY
FRESNEL CENTER
T0
T1
T2
P1
P2
B
40°
SA2
C
51A

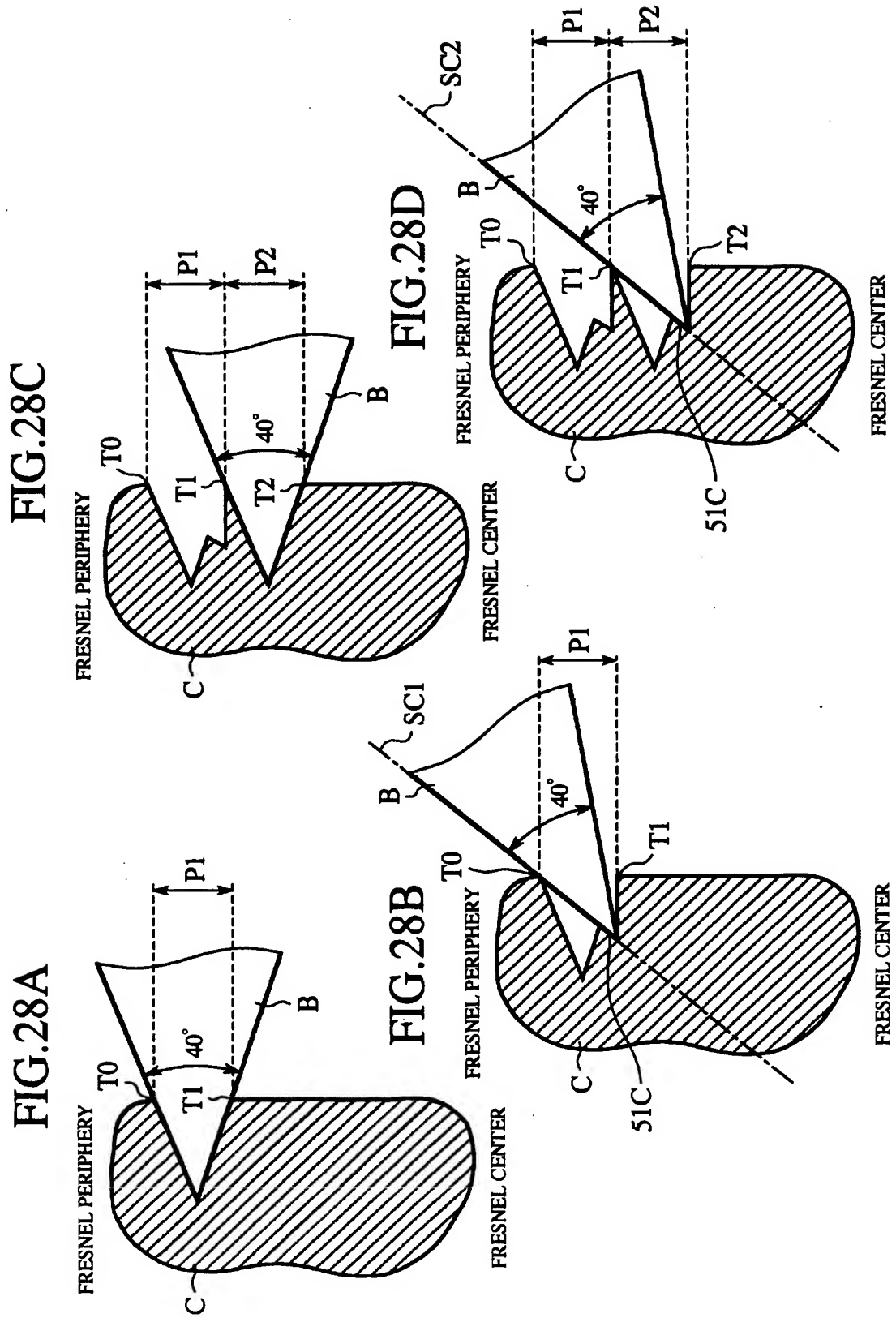


FIG.28A
FRESNEL PERIPHERY
T0
T1
40°
B
C
P1
FRESNEL CENTER
FIG.28B
SC1
FIG.28C
T2
P2
FIG.28D
SC2
51C

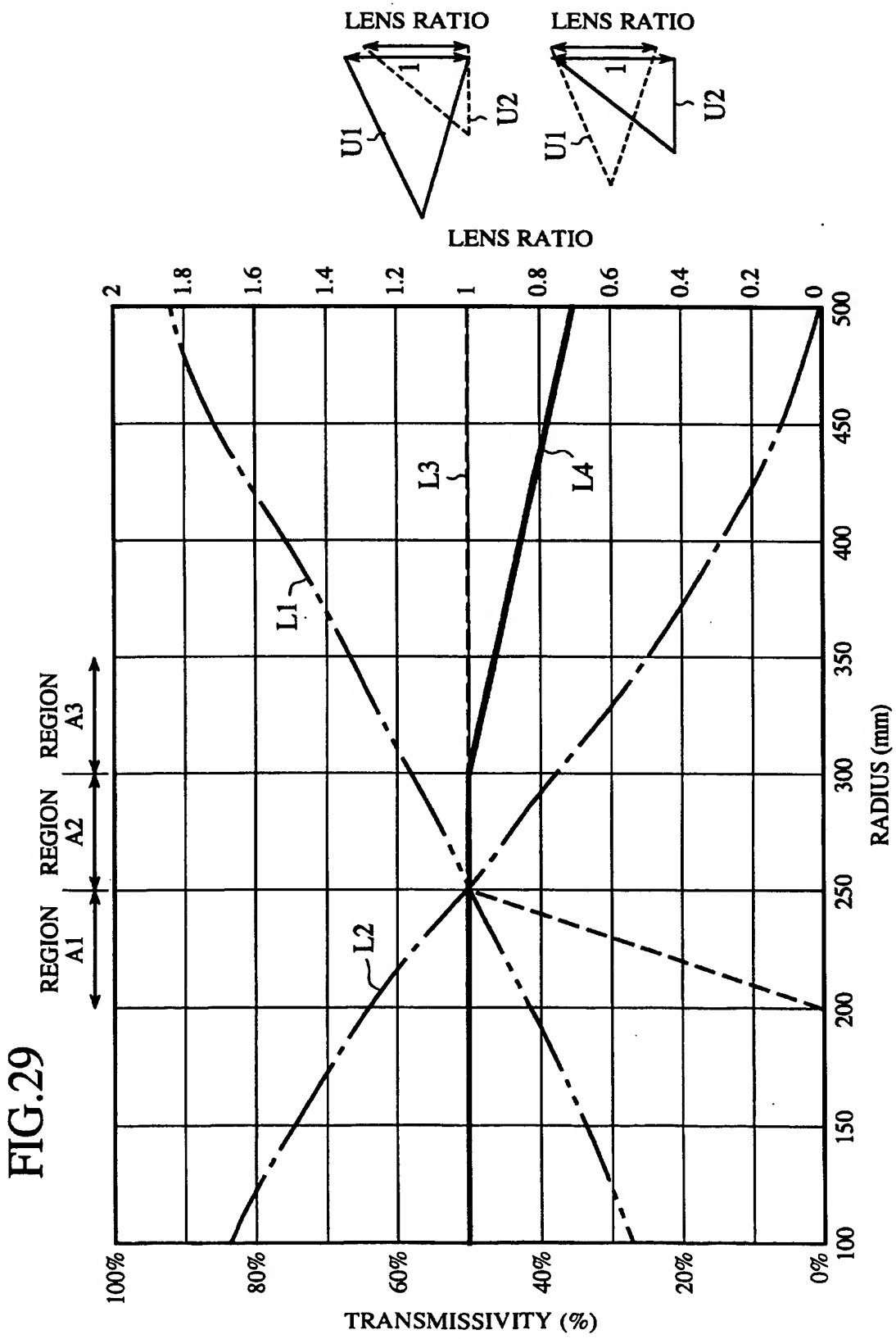

LENS RATIO
LENS RATIO
U1
U2
1
U1
U2
1
LENS RATIO
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
L1
L2
L3
L4
REGION A1
REGION A2
REGION A3
100%
80%
60%
40%
20%
0%
TRANSMISSIVITY (%)
500
450
400
350
300
250
200
150
100
RADIUS (mm)

FIG.29

FIG.30

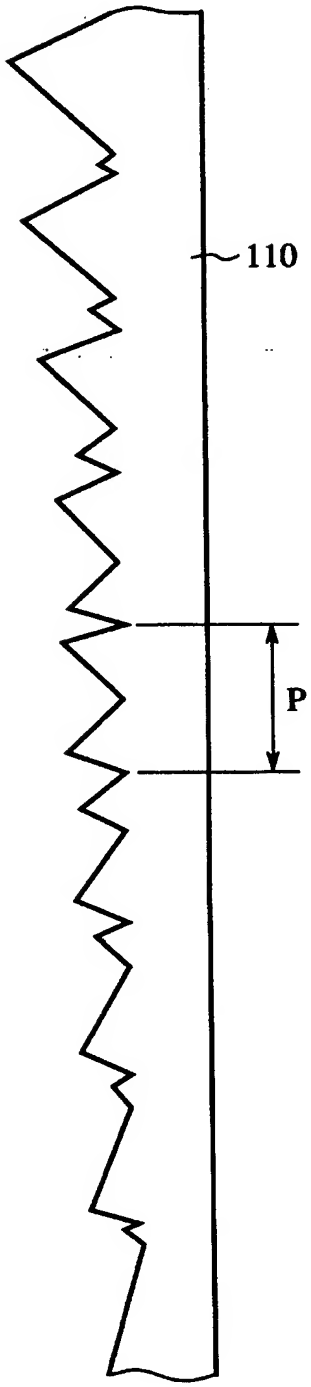


FIG.31

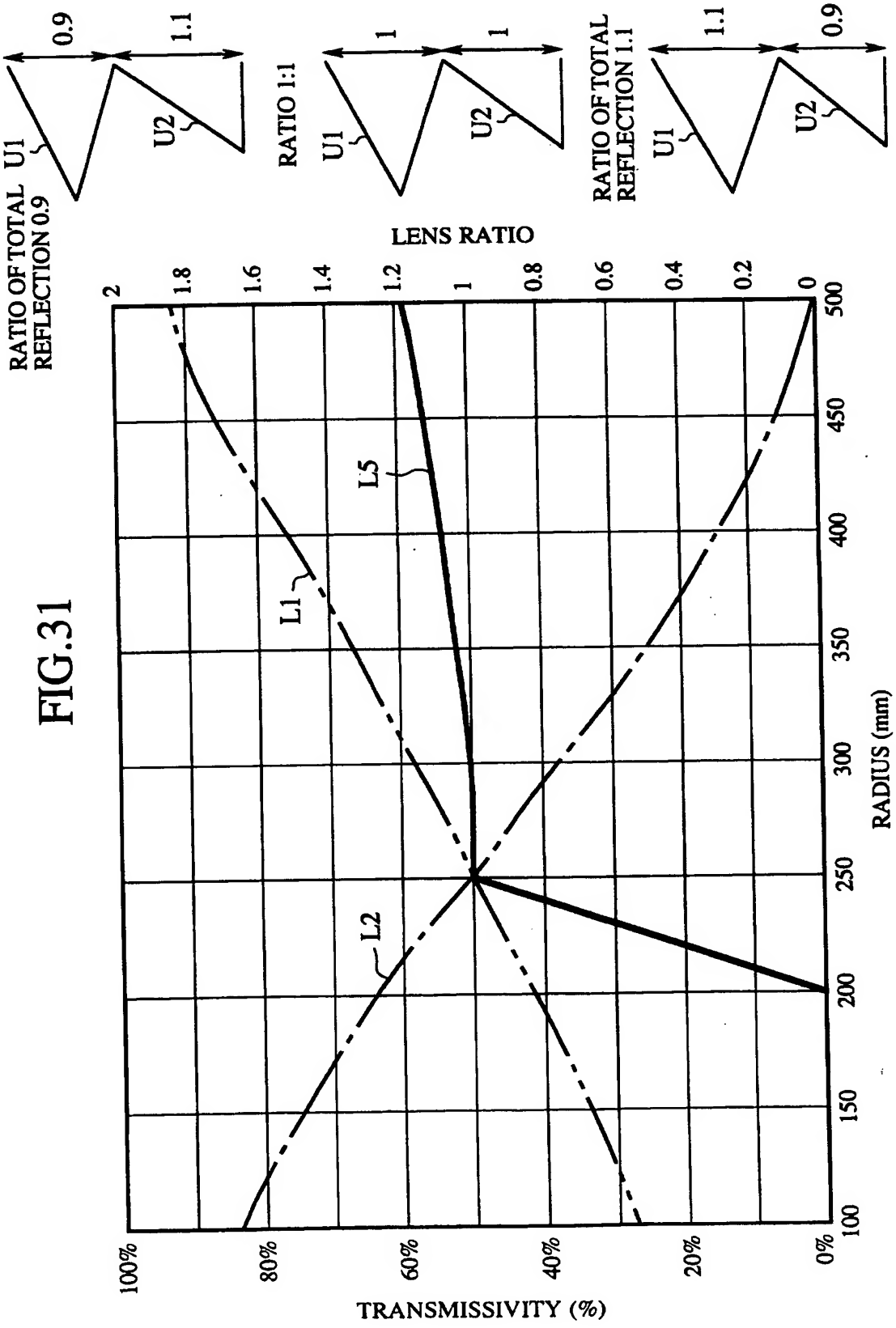

RATIO OF TOTAL REFLECTION 0.9
0.9
1.1
U1
U2
RATIO 1:1
1
1
U1
U2
RATIO OF TOTAL REFLECTION 1.1
1.1
0.9
U1
U2
LENS RATIO
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
L5
L1
L2
500
450
400
350
300
250
200
150
100
RADIUS (mm)
100%
80%
60%
40%
20%
0%
TRANSMISSIVITY (%)

FIG.32

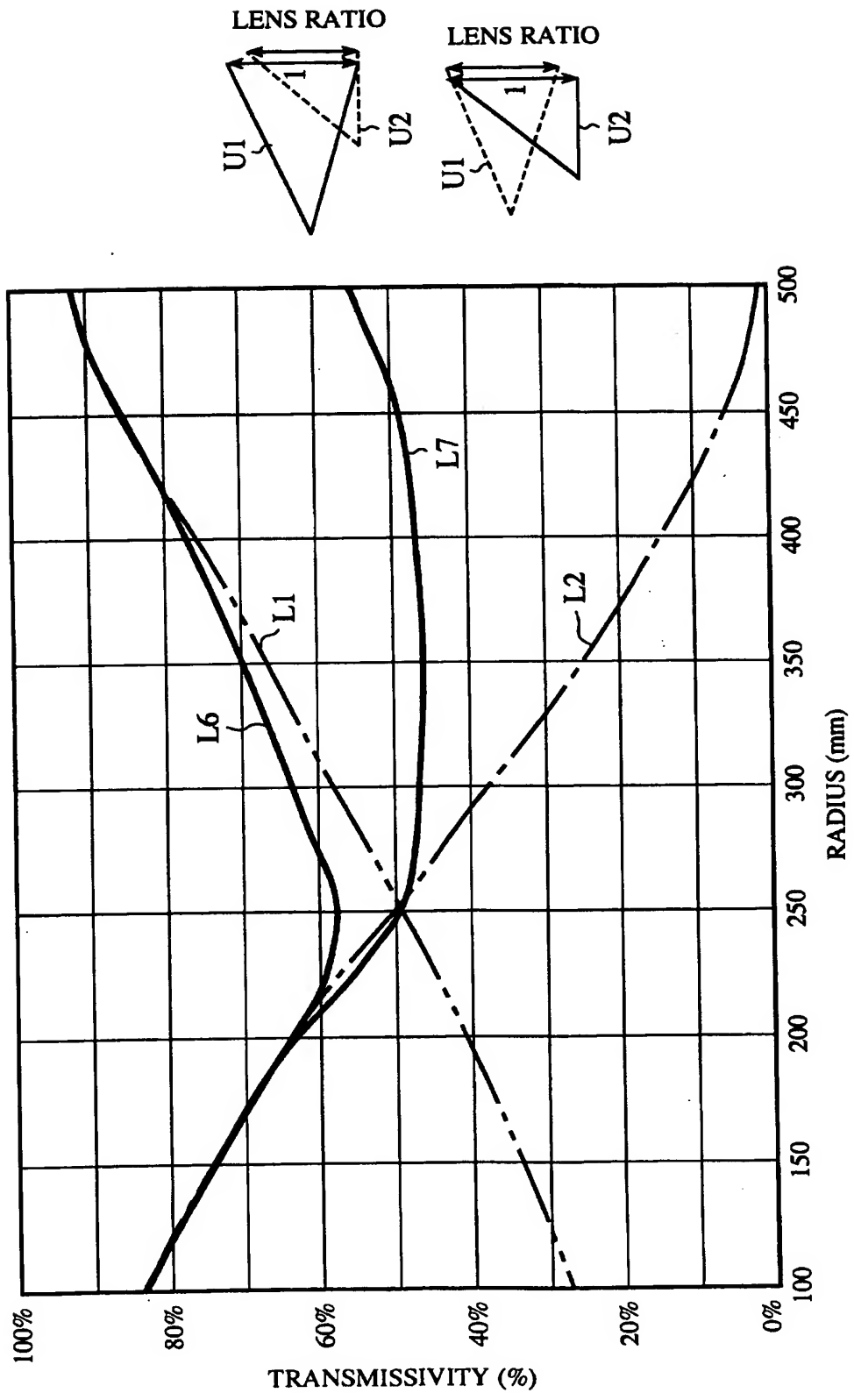

LENS RATIO
1
U1
U2
LENS RATIO
1
U1
U2
L7
L1
L2
L6
100%
80%
60%
40%
20%
0%
TRANSMISSIVITY (%)
100
150
200
250
300
350
400
450
500
RADIUS (mm)

FIG.33A

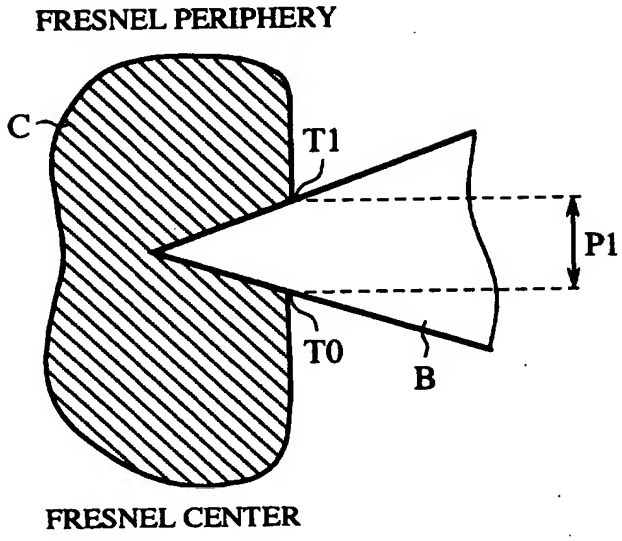


FIG.33B

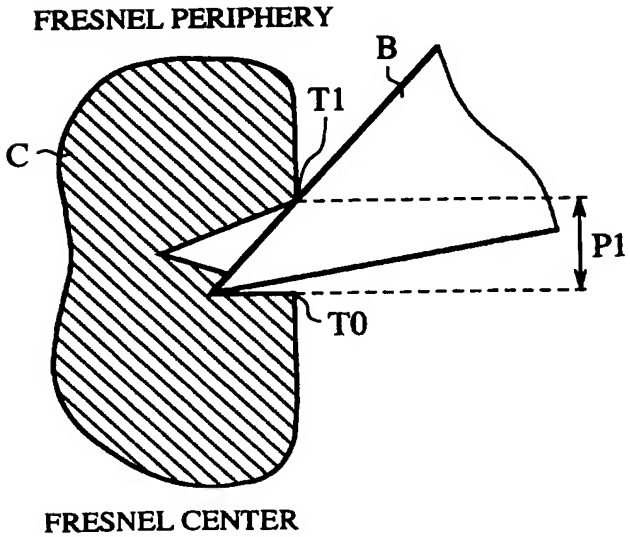


FIG.33C

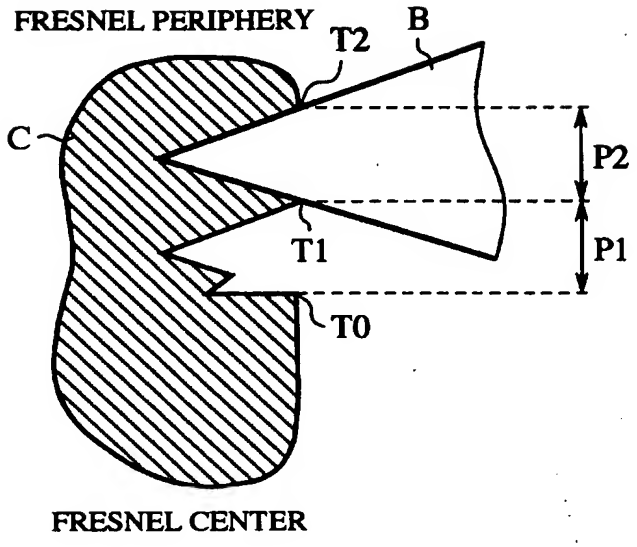


FIG.33D

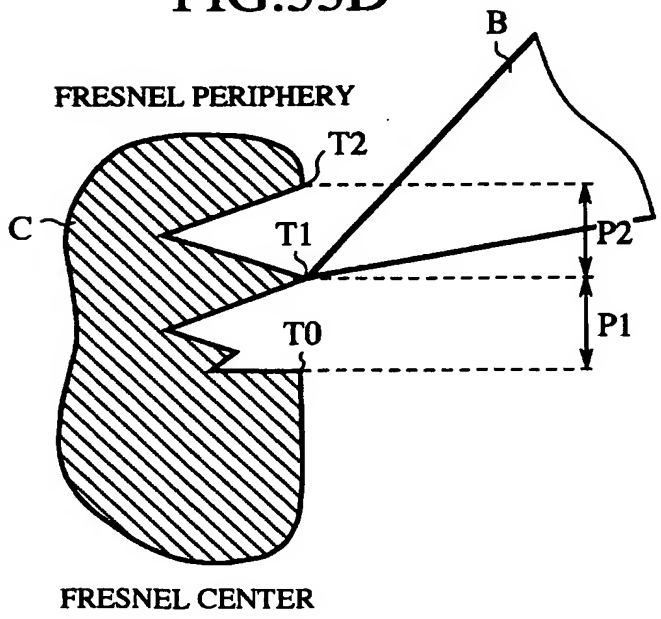


FIG.33E

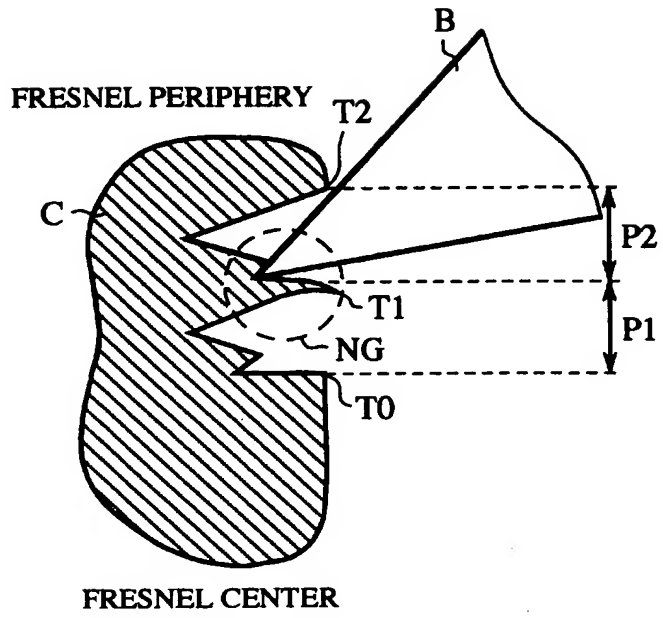


FIG.33F

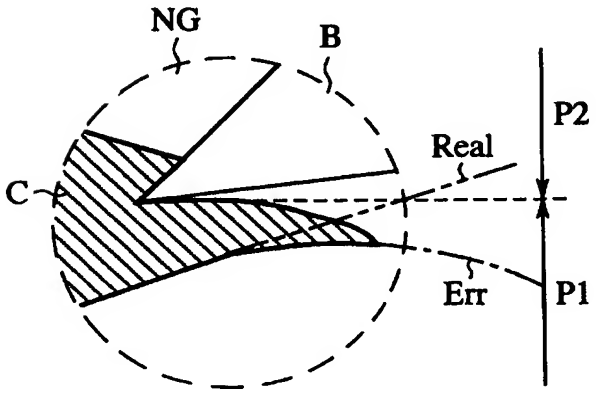


FIG.34

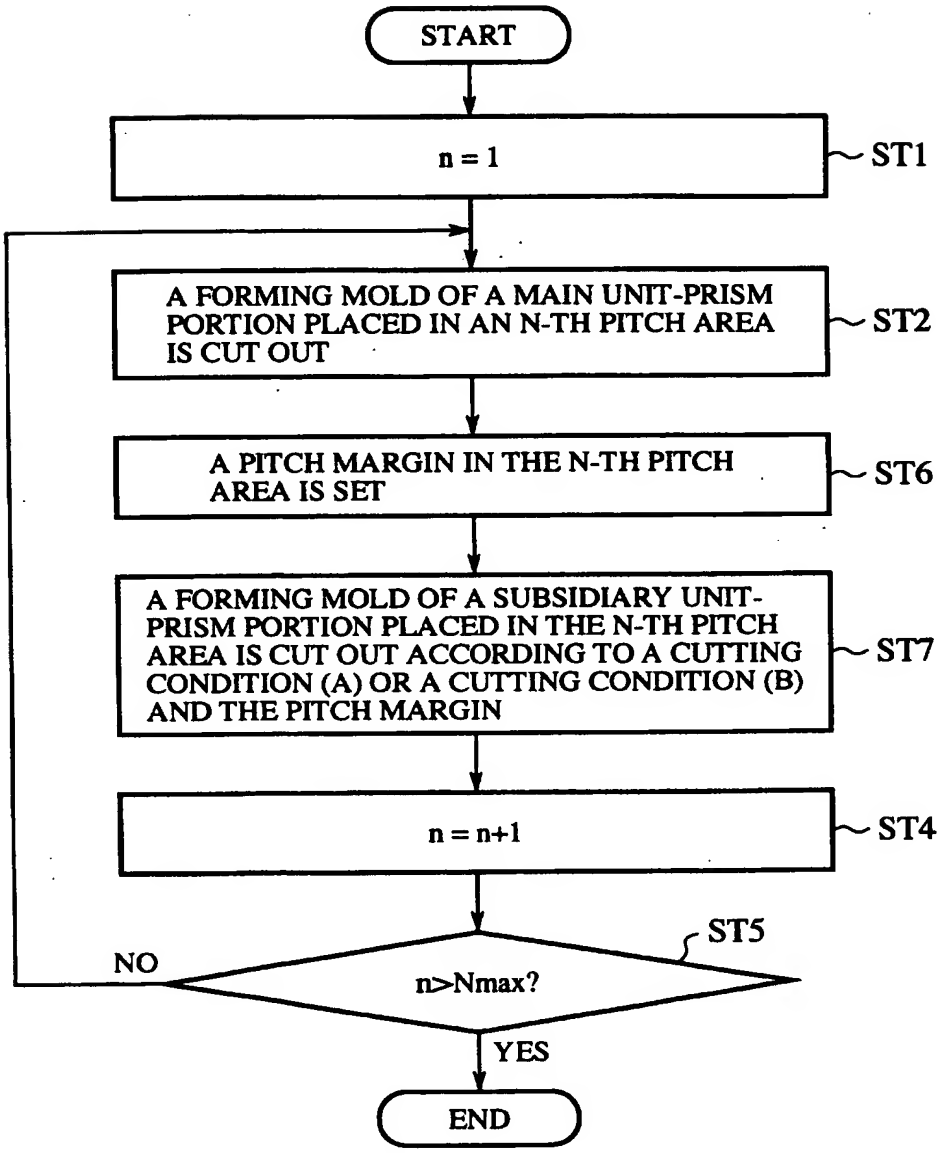

START
n = 1
ST1
A FORMING MOLD OF A MAIN UNIT-PRISM PORTION PLACED IN AN N-TH PITCH AREA IS CUT OUT
ST2
A PITCH MARGIN IN THE N-TH PITCH AREA IS SET
ST6
A FORMING MOLD OF A SUBSIDIARY UNIT-PRISM PORTION PLACED IN THE N-TH PITCH AREA IS CUT OUT ACCORDING TO A CUTTING CONDITION (A) OR A CUTTING CONDITION (B) AND THE PITCH MARGIN
ST7
n = n+1
ST4
ST5
NO
n>Nmax?
YES
END

FIG.35A

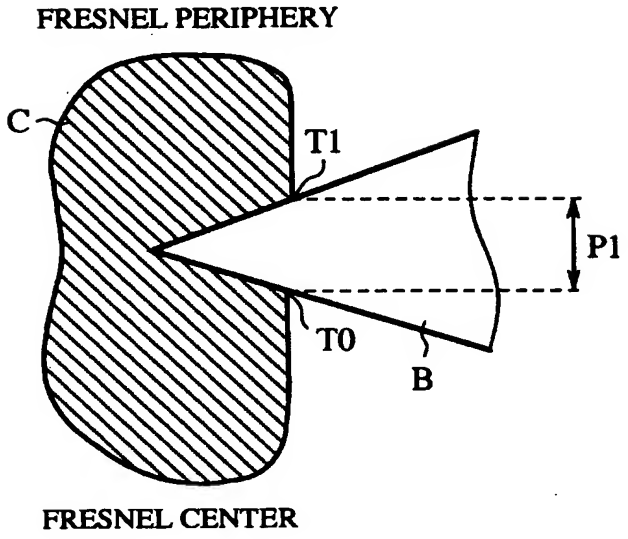


FIG.35B

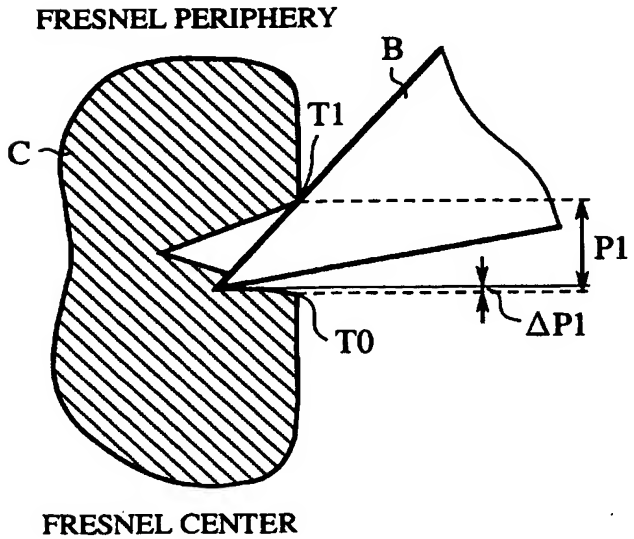


FIG.35C

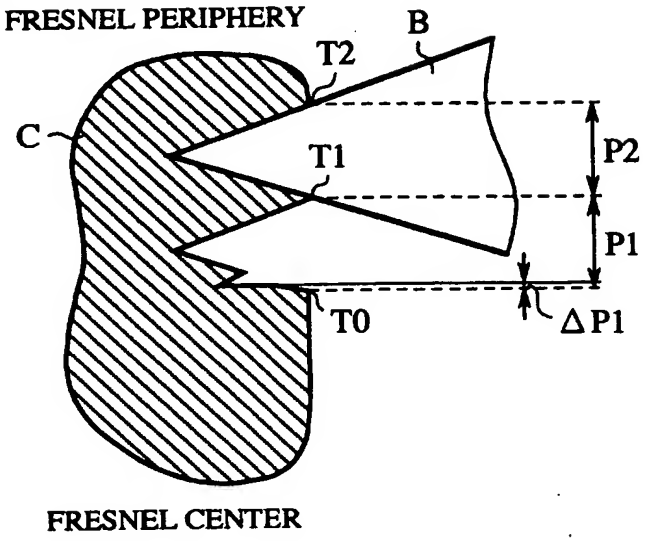


FIG.35D

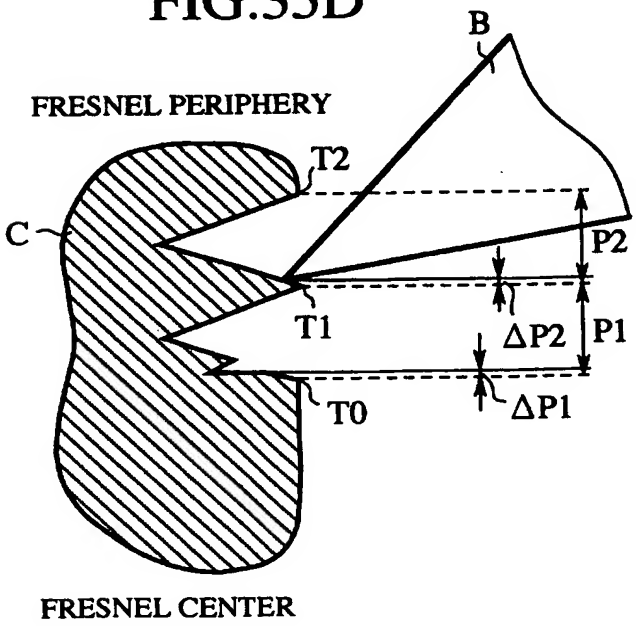


FIG.35E

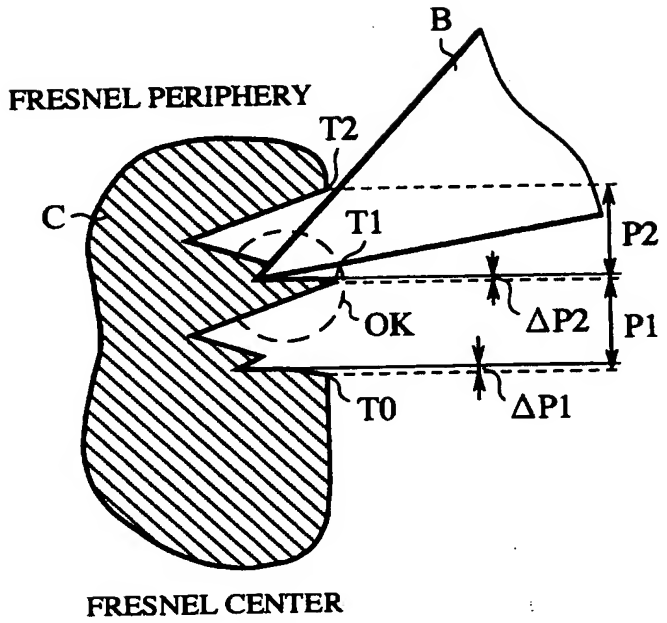


FIG.35F

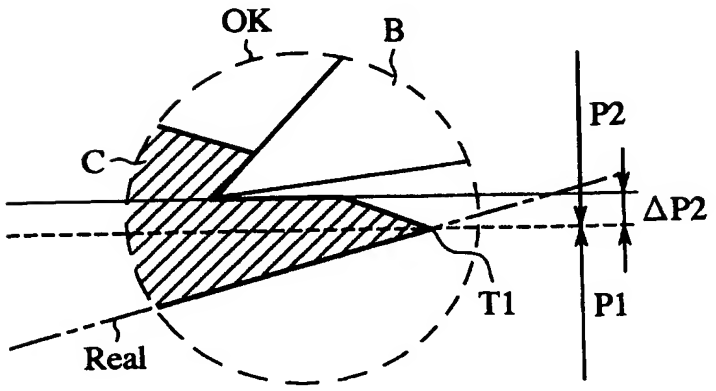


FIG.36A

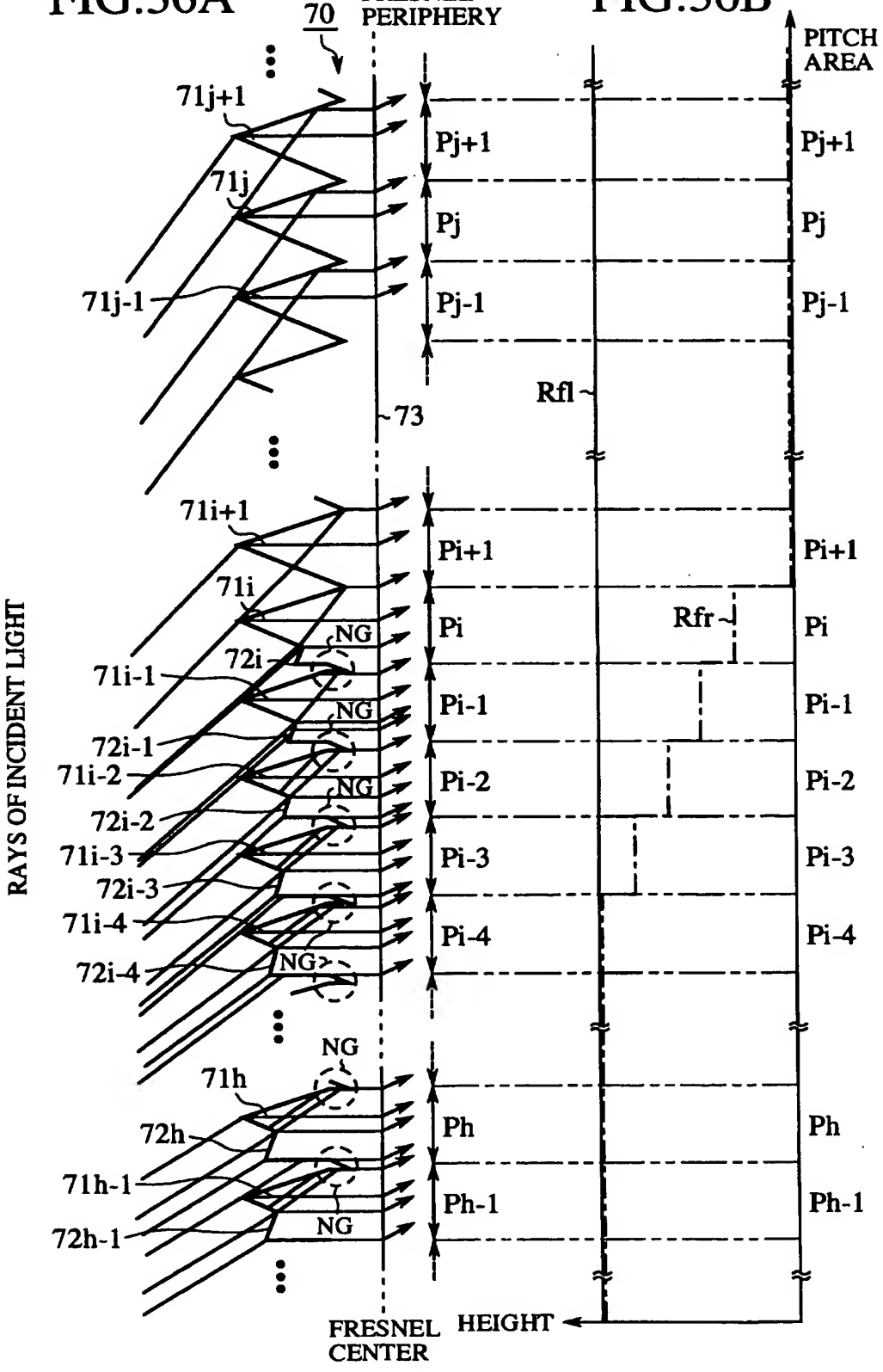


FIG.36B

FIG.37A

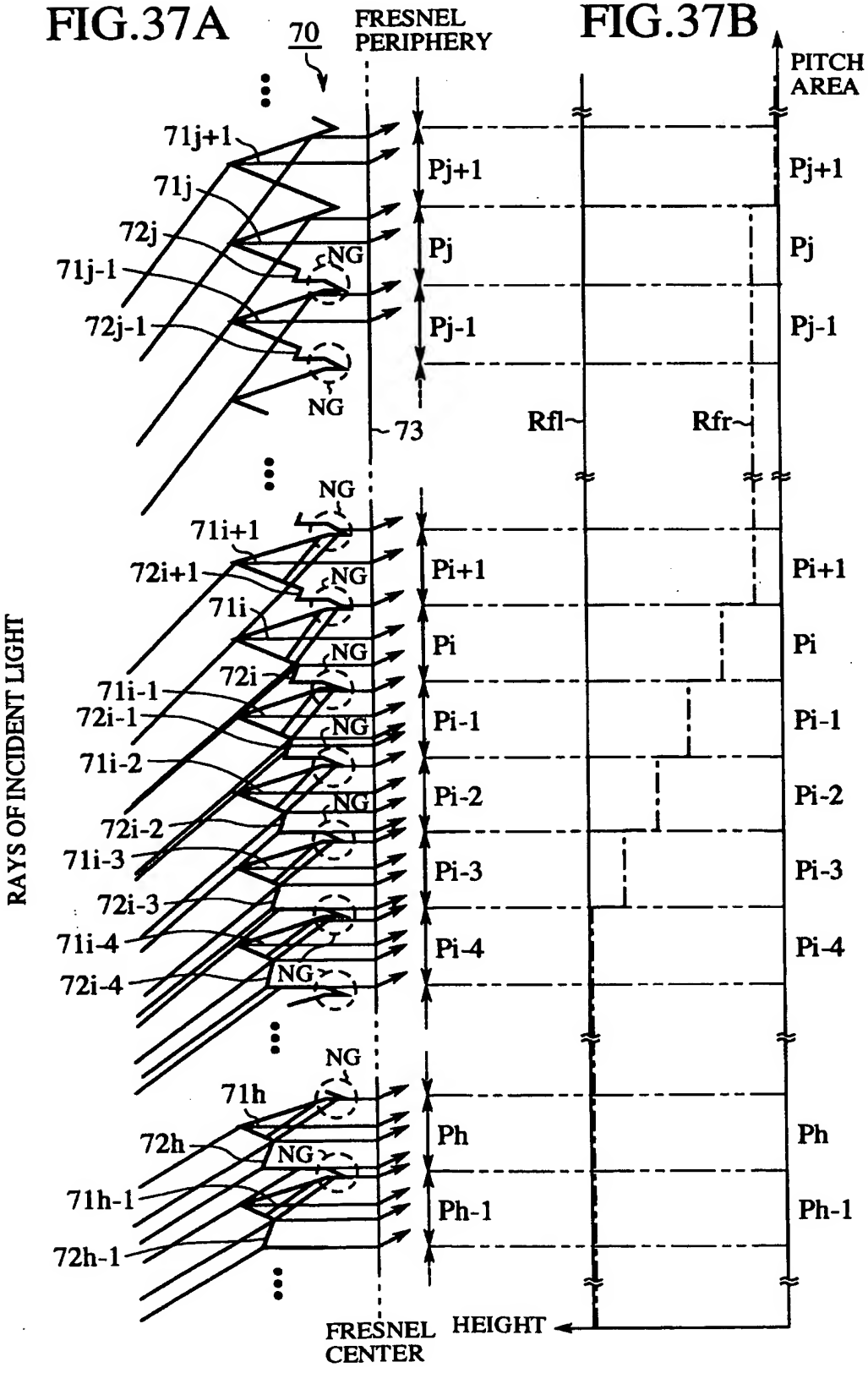

70
FRESNEL PERIPHERY
71j+1
71j
72j
71j-1
72j-1
NG
73
RAYS OF INCIDENT LIGHT
71i+1
72i+1
71i
72i
71i-1
72i-1
71i-2
72i-2
71i-3
72i-3
71i-4
72i-4
71h
72h
71h-1
72h-1
FRESNEL CENTER
FIG.37B
PITCH AREA
Pj+1
Pj
Pj-1
Rfl
Rfr
Pi+1
Pi
Pi-1
Pi-2
Pi-3
Pi-4
Ph
Ph-1
HEIGHT

FIG.38A

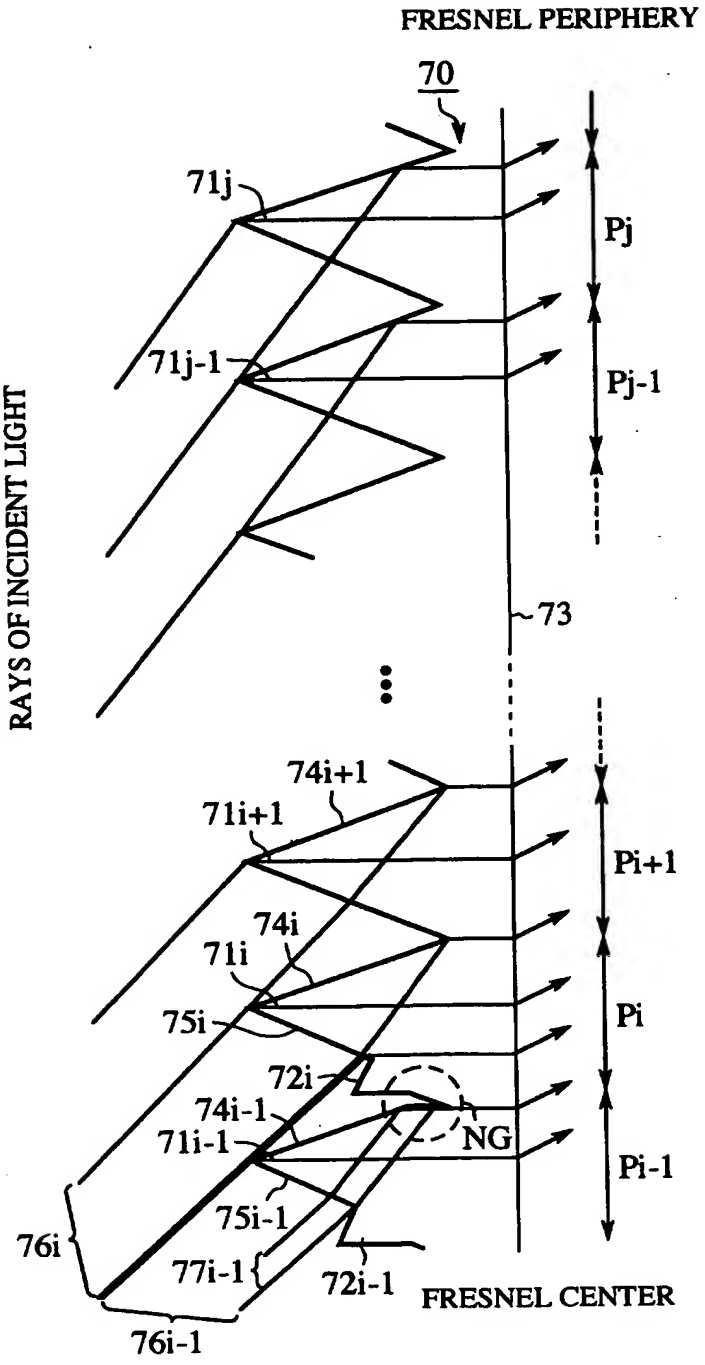

FRESNEL PERIPHERY
70
71j
Pj
71j-1
Pj-1
RAYS OF INCIDENT LIGHT
73
74i+1
71i+1
Pi+1
74i
71i
75i
Pi
72i
74i-1
NG
71i-1
Pi-1
75i-1
76i
77i-1
72i-1
FRESNEL CENTER
76i-1

FIG.38B

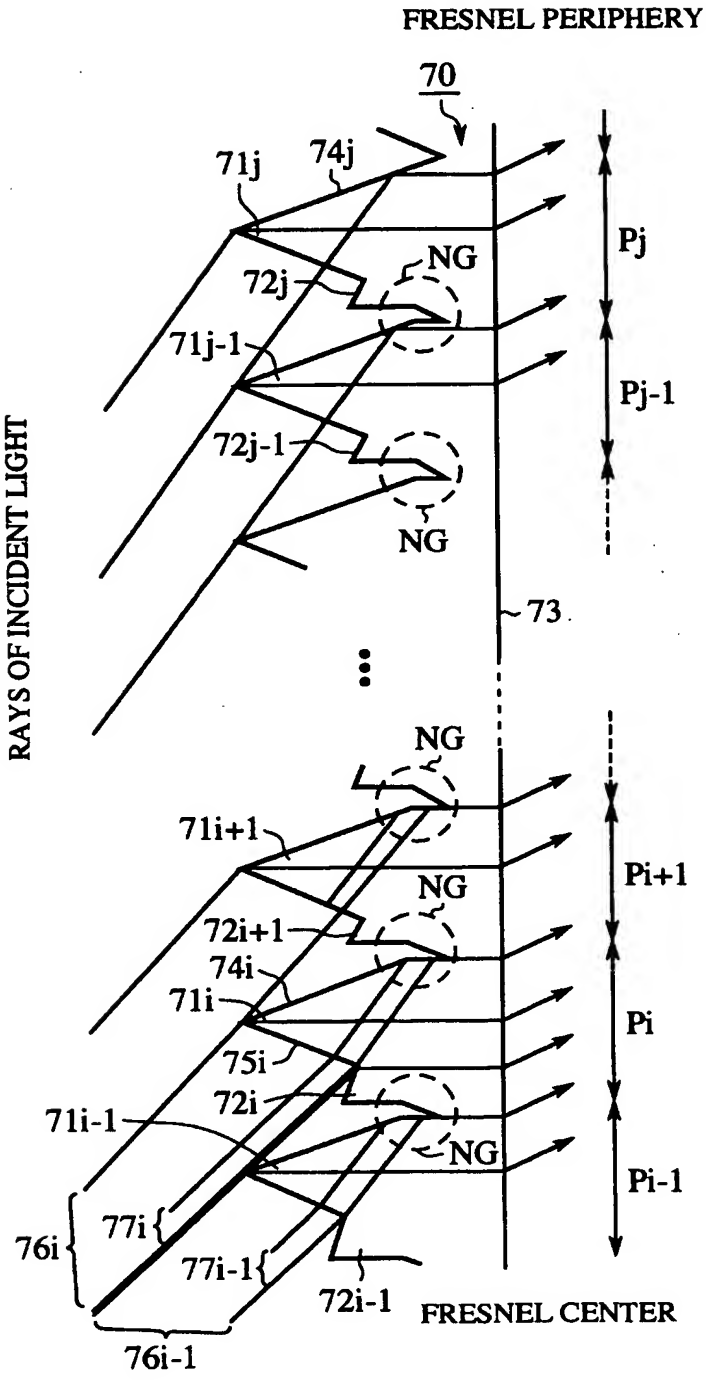

FRESNEL PERIPHERY
70
71j
74j
NG
72j
71j-1
72j-1
NG
Pj
Pj-1
RAYS OF INCIDENT LIGHT
73
NG
71i+1
NG
72i+1
74i
71i
75i
72i
71i-1
NG
77i
76i
77i-1
72i-1
76i-1
Pi+1
Pi
Pi-1
FRESNEL CENTER

FIG.39

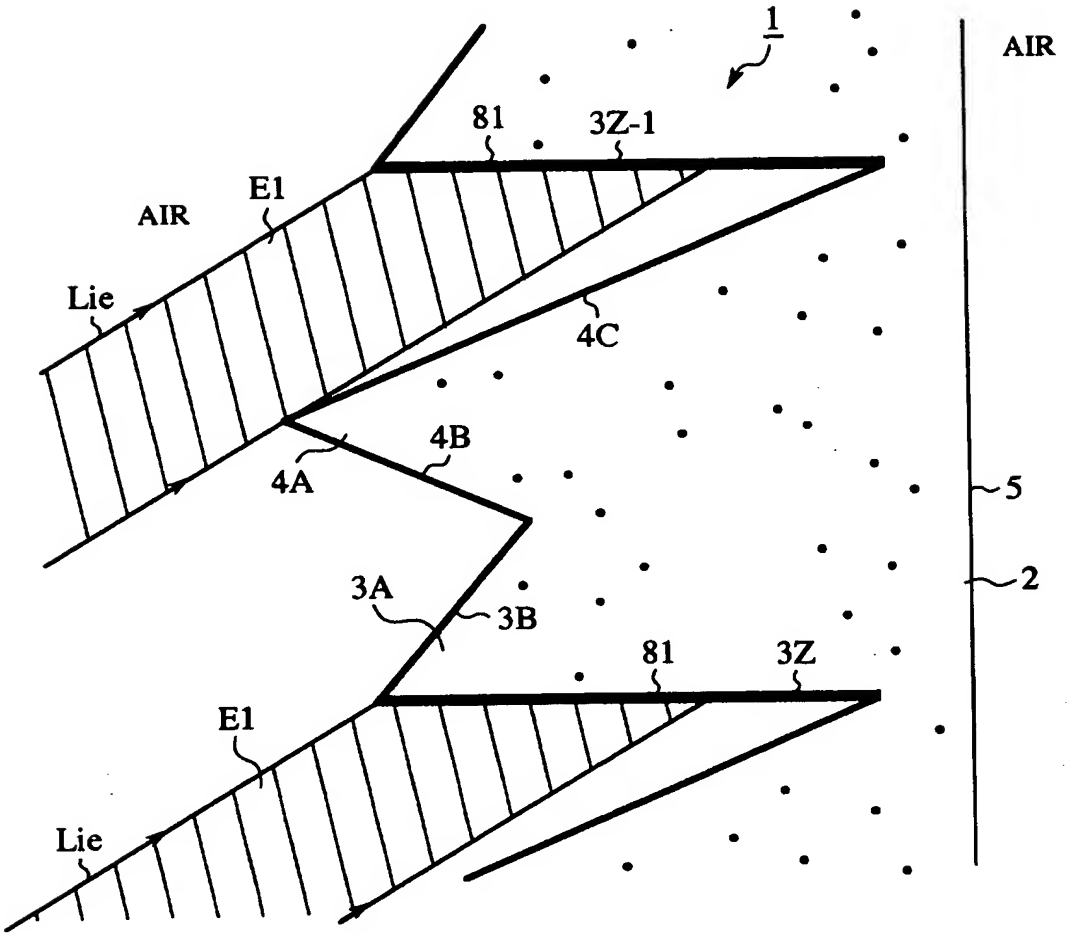


FIG.40

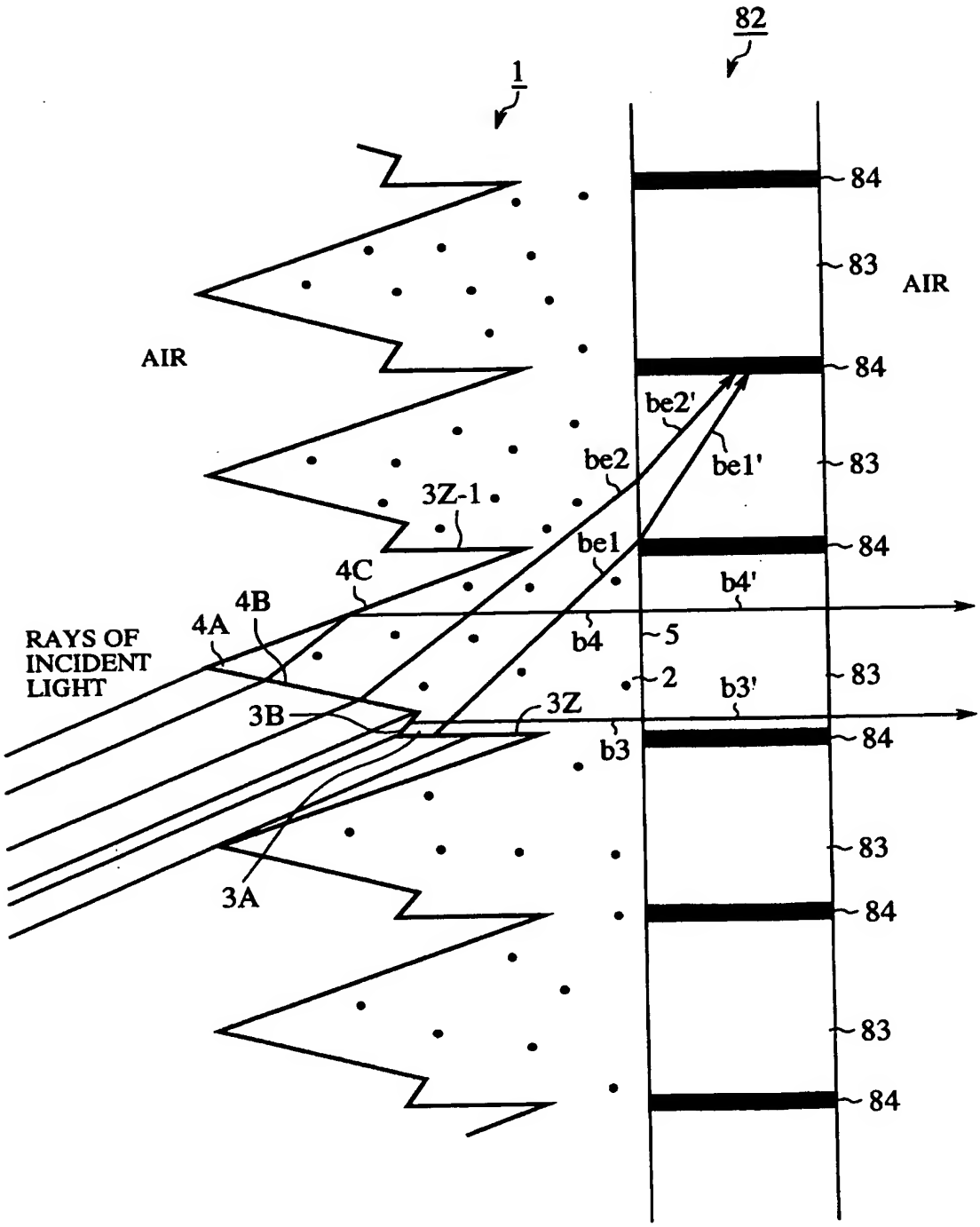

82
1
84
83
AIR
AIR
84
be2'
be2
be1'
83
3Z-1
be1
84
4C
b4'
4B
4A
RAYS OF
INCIDENT
LIGHT
b4
5
2
b3'
83
3B
3Z
b3
84
83
3A
84
83
84

FIG.41A

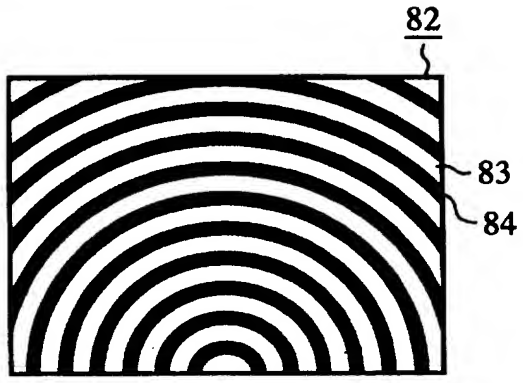


FIG.41B

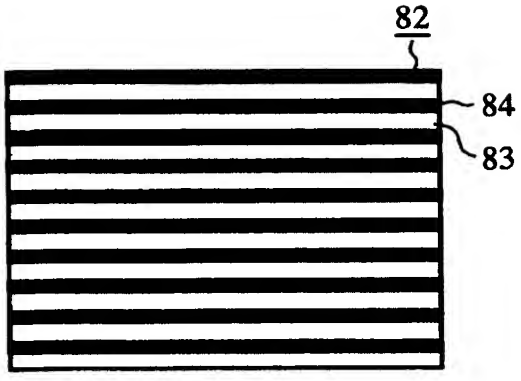
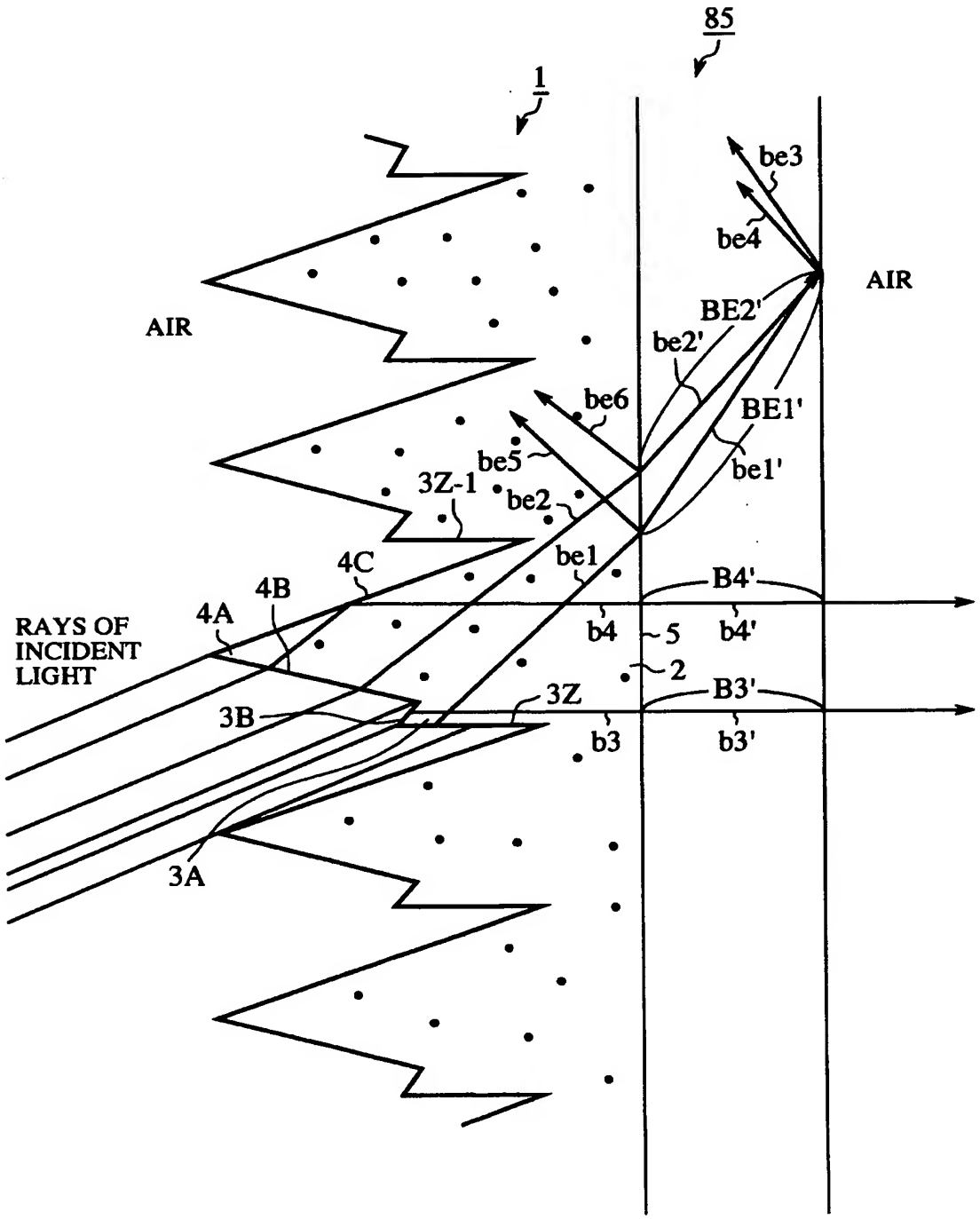


FIG.42


85
1
be3
be4
AIR
AIR
BE2'
be2'
be6
BE1'
be5
be1'
3Z-1
be2
be1
4C
4B
4A
B4'
RAYS OF
INCIDENT
LIGHT
b4
5
b4'
2
3Z
B3'
3B
b3
b3'
3A